

SOIL CONSERVATION SERVICE RESEARCH
U. S. DEPARTMENT OF AGRICULTURE

Washington, D. C.

SUMMARIES OF ANNUAL REPORTS
OF
RESEARCH PROJECT SUPERVISORS
FOR
CALENDAR YEAR 1948

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December 15, 1949

SUMMARY OF ANNUAL REPORTS FOR CALENDAR YEAR 1948

R-1, EROSION CONTROL PRACTICES DIVISION

Auburn, Alabama, E. C. Richardson, Project Supervisor. During the past four planting seasons, 1944 to 1948, kudzu plantings were made on different dates and by different methods. Three methods of plantings were used: hole method, shallow furrow, and deep furrow method. Plantings were made on three dates: December, January, and February.

There was little difference in the survival of kudzu plants planted by the different methods. Best survivals were obtained from plantings made in February. Higher survivals were obtained in South Alabama than in North Alabama. Results indicate that kudzu may be successfully planted from November on, thereby using effective labor and equipment in off seasons.

In the kudzu spacing study, plants were spaced 3-1/2 feet in the drill. Rows were spaced 4, 8, 16 and 24 feet apart. Superphosphate was applied at a constant rate per acre and at a constant rate per plant.

The average yield of kudzu did not differ greatly as a result of the different spacings. Where fertilizer was applied at a constant rate per acre, yields in 1948 were higher where rows were spaced 8 and 16 feet apart. When fertilizer was applied at a constant rate per plant, higher yields per acre were obtained when spaced 4 feet apart.

Phosphate and potash were applied in different amounts to kudzu growing on Cecil soil at North Auburn. Yield determinations were made in late June each year, by cutting definite areas in each treatment. After making yield determinations, the entire area was cut for hay. A crown density study was made in early 1948, to determine the effect of fertilizer on plant population.

Superphosphate applied at the rate of 200 pounds per acre increased the yield of green kudzu on the noneroded area approximately 1,000 pounds and on the older area approximately 4,000 pounds per acre over the no-treatment plots. The application of 400 pounds of superphosphate doubled the increase on the respective areas. Potash application resulted in some increase.

In the crown study, 97,405 kudzu crowns per acre were obtained from the area which received no fertilizer treatment. Approximately 70,000 plants per acre were obtained where 400 pounds of superphosphate per acre were applied. Fertilizer applications increased the vigor of the kudzu plants, which produced a very dense shade over the less vigorous plants.

Fertilizer treatments similar to those applied to kudzu were also applied to lespedeza sericea growing on Cecil soil. Yield of cover, sericea plant population, and broomsedge population were determined for various treatments.

Sericea without any fertilizer produced approximately 9,000 pounds of green material per acre. Superphosphate applied at the rate of 200 pounds per acre increased the production approximately 9,000 pounds of green sericea per acre. The application of 400 pounds of superphosphate per acre increased the yield of green sericea 200 to 500 pounds over that produced where 200 pounds of superphosphate were applied.

In the sericea area where no fertilizer was applied, there were 1,200,000 sericea plants growing per acre. Where heavier rates of fertilizers were applied the number of sericea plants was reduced to approximately 800,000 plants per acre.

Approximately 100,000 broomsedge plants per acre were growing in the sericea which received no fertilizer treatments. The broomsedge plants were reduced to less than 600 plants per acre where 400 pounds of superphosphate and 100 to 200 pounds of muriate of potash were applied per acre.

Caley peas and grandiflora vetch have each produced three volunteer stands from seed that matured on the land in 1945. The three-year-average yield of green manure produced was 16,000 pounds per acre for Caley peas and 13,000 pounds per acre for grandiflora vetch. The third volunteer stand was allowed to mature a satisfactory crop of seed in 1948. Volunteer stands of vetch and peas are growing on this area now.

Grain sorghum, following these legumes after maturing seed, produced 45 bushels of grain sorghum per acre. Corn yields in the other two years produced 60 and 50 bushels per acre.

Legume residue, the seed-production year, was turned in a mature condition. In a mature condition, it was more resistant to decay; therefore, it remained in the soil much longer than green material. Excellent growth of vetch and peas were turned for two corn crops. The increase in nitrogen from turning the legume crop resulted in large yields of mature residue from the grain crop.

The practice of combining mature residue and green legumes is reducing soil losses, building soil, and improving crop yields.

Tucson, Arizona, Joel E. Fletcher, Project Supervisor. The work of this project in Arizona followed the general pattern of the past several years, along the line of the five approved projects. These projects are still not at completion, so only progress can be reported.

The eradication of burroweed may be successfully and economically accomplished by mowing in June or early July, before the summer rains begin. If reseeding is contemplated it is a more efficient process to allow the shrub to be eradicated by the eccentric disk during the seeding process. It is an economical and practical procedure to re-seed Southern Arizona Ranges with Lehmann lovegrass by means of the eccentric disk and the cultipacker seeder. Seeded solid and including the AAA payment, the cost should be below \$1600 per section. In strips this should be reduced below \$640 per section. The latter procedure is cheaper per unit of increase in income on a five-year basis.

"Piping" is a destructive and insidious type of erosion which has laid waste as much as 30% of some areas of Arizona's rich bottom lands. Because of the insidious nature of the tunnels, it has not been recognized as the menace that it is until recently.

Several soils which are affected with this malady have been investigated. It was found that piping only occurs when the substratum is lower in permeability than the soils above it, when there is a ready outlet for the resultant lateral flow, and when there is a source of water.

Laboratory analyses provided the following information regarding soils properties with this condition: exchangeable sodium, percent sodium in the complex, pH, and total soluble salts. The obvious cures lie in the realm of cutting off either the outlet or the source of water.

Some of the properties of water solutions which influence the rate at which water infiltrates into soil were investigated. Poiseuille's approximation was altered in such a way as to show the effects of viscosity, surface tension, pore size, length of pores, and wettability or angle of contact between solid and solution on infiltration. Brief experimental confirmations of the theory were given. It was pointed out that the wettability would explain some of the mysteries in the infiltration process as it applies to dry soils.

Moisture studies were somewhat contracted during 1948, due to the economic status of grapefruit in Arizona and to the water shortage. Records should be resumed in 1949, since the top-worked trees will be large enough to work with by summer. This experiment was replicated on the Yuma Mesa in a sand. Measurements should begin in the near future. In 1948, another use for the capacitance meter was found. It appears that it will prove to be an effective means for determining total forage on pastures or range lands.

Two papers on the above subjects appeared in print and three more were approved for publication during 1948.

Batesville, Arkansas, George W. Hood, Project Supervisor. This project was begun in 1939 and consisted of 10 plots of 1/16 acre, 2 plots of 1/10 acre, and 2 one-acre plots. In 1941 two more plots were added to the group, making a total of 16 plots, all on approximate 4% slope. The rows were 90 and 200 feet. Farming with the slope and on the contour was established. A three-year rotation of cotton, corn, and oats was adopted, in combination with vetch and lespedeza, as soil-building crops.

Soil losses for an 8-year period on continuous cotton planted with the slope, on 90-foot rows, have averaged 23.4 tons per acre, while on 200 foot rows the average loss was 42.7 tons per acre.

Continuous cotton planted on the contour averaged 10.54 tons of soil lost per acre, and where cotton was grown in a three-year rotation and planted on the contour, the average loss of soil was 4.98 tons per acre per year. Where all three crops were planted in strips, on the same piece of ground the same year, the average yearly soil loss was 3.34 tons per acre.

There was no one month which produced the greatest soil loss. During the 8-year period, every month has produced high soil loss. The records for this period indicate that the greatest amount of soil loss is most likely to occur during March, April, May and June, although in some years, December, January, and February have produced the heaviest soil loss for the year.

The loss of soil for the past 8 years has been greater from corn than it has from cotton, with the same tillage practices. Under the condition of our experiments both erosion and runoff have been less from cotton than from corn. The runoff from oats was about equal to that of corn, but the soil lost from oats was only about 1/2 as great as that from corn.

A good rainfall distribution, with ample supply at critical periods, during 1948 produced some very high yields of corn. One plot on Baxter soil produced at the rate of 101 bushels per acre; with an average of 89 bushels for two plots, grown in a three-year rotation, on the contour. The average yield on Ozark soil when grown in contoured strips, in rotation was 82 bushels.

The average yield of seed cotton, for a six-year period was 587.5 pounds, when grown in a 3-year rotation of cotton, corn, and oats on Baxter soil, under conservation practices. This yield was almost 4 times larger than where continuous cotton was grown with no conservation practices, which produced only 150.5 pounds per acre.

The average yield for a 6-year period on Ozark soil under conservation methods was 793 pounds of seed cotton, as compared with 437 pounds where no conservation was used. These results should prove conclusively the value of conservation farming.

The past 8 years, kudzu has been grown on a badly eroded area. The study and observation of this planting of kudzu clearly indicates the value of the plant, and establishes for it a very definite place in our agricultural economy and in erosion control. Many areas can be made productive by introducing kudzu. The plant has proven to be valuable as feed for stock. While harvesting kudzu for hay is difficult on such sites, the crop can be successfully pastured if properly managed. Stock is especially fond of it and for that reason grazing is essential. Kudzu may fit into several crop rotations, and serve as a valuable contribution to agriculture.

Lespedeza sericea is another plant that has demonstrated its value for producing good hay as well as being a good soil-building and soil-improving crop. It is also a good pasture plant, especially for use early in the spring. It grows well on many soils, and is easily established on poorer land. It has made good growth on Class 4 and 6 land. Our observation of sericea planted on Class - 4 land has been that it starts slowly but maintains itself and improves each year. By the third year it has developed into an excellent plant which will provide early pasture and will produce one and usually two fine crops of hay, the value of which compares favorably with that of alfalfa. This plant will grow well in many areas where alfalfa will not grow, and has a wide range of possibilities. It is adapted to both heavy and light soils, and does the best on well drained areas.

Sericea also has other uses, and is especially valuable for planting in gullies. We have had very satisfactory results by simply broadcasting the seed on areas too rough or stony to attempt any kind of soil preparation. Rough areas where the plant is not harvested, soon thicken up by re-seeding. Sericea should be fertilized, to build up and maintain its stand. The amount or kind of fertilizer depends upon the soil. There are about 85 farms now growing sericea in this district, and its value is fast being appreciated.

Strip cropping continues to demonstrate its value as a means of conserving soil and water. The records this year showed that crops planted on the contour in strips lost about 1/8 as much soil as where the crops were planted with the slope. Similar results were seen in the loss of water which was about 1/5 as great as that lost from continuous crops planted with the slope; in other words, strip cropping saved 8 times more soil and 5 times more water. These two factors add up to increased yields, and a better economy for the farmer.

Strip cropping on Ozark soil planted on the contour, in a three-year rotation of cotton, corn and oats, with vetch and lespedeza to build up the soils, lost 3.57 tons of soil and 1.43 inches of water as contrasted with continuous cotton, grown with the slope which lost 27.86 tons of soil and 7.26 inches of water.

A three-year rotation, of cotton, corn and oats planted as fields, and not as strips, also proved superior to non-conservation practices, where approximately 6 times more soil and 4 times more water was saved on Baxter soil for use of the crops.

Riverside, California, Dr. Maurice Donnelly, Project Supervisor.

Work has been continued during 1948 on erosion control and moisture conservation on grainland, as well as on measures for wind erosion control in vineyards. The grainland studies were carried on in cooperation with Operations at the Haskell and Houston plots in the San Geronio Soil Conservation District.

1. Reclamation of Abandoned Grainland.

When land is abandoned for grain culture, it is seldom done by entire fields. Rather, a gullied area is abandoned or a marginal strip of badly worn soil goes out of production. At the Haskell Plots in the San Geronio Soil Conservation District, a good-sized tract of land at the western margin had been recently abandoned for cultivation. It was not included in regular experimentation. The new legume, blue lupine (new to this zone) was planted on this abandoned land in the fall of 1945. Seed was inoculated with the correct bacterial inoculum. Plants made fair growth the first year. No cultivations were performed or carried out in the spring of 1946. In the fall of 1946, an unusual period of wet weather caused a high percentage of seeds that had lodged on the ground to germinate and grow. These plants made heavy growth. In the spring of 1947, the seed crops was estimated at about 500 pounds of dry seed per acre. The land was disked in the spring of 1947 and prepared for barley cropping. A better than average crop of barley was harvested from this land in the summer of 1948. As noted in the summary on grain yields from the Beaumont plots for the season 1947-48, the yield of barley, 1760 pounds per acre, from this reclaimed land exceeded that from the standard plow plots, 1460 pounds per acre.

2. Winter Annual Grass Cover Crop in Grape Vineyards.

It has been felt for a long time by many conservationists who have studied the problem that a winter cover crop in this subtropical climate would not, if properly handled, use much more water consumptively than would be lost by evaporation under a system of continuous fallow. We previously had no opportunity to test this idea because on heavy soils it is frequently not possible to reduce the cover crop at the right time. The soils of the wind area, where these studies were made, are sandy with a single grain structure. Hence it is

possible to reduce cover crop growth at almost any given selected time. In Table A, the data on cover crop growth and subsequent grape yields are given. Although the season 1947-48 was unfavorable with respect to rainfall and soil moisture supply, no reduction in yield of the summer-growing grapes was found on plots where cover crop (cereal rye grass) had made strong growth.

Response to Cereal Rye Winter Cover Crop to Fertilizers.

The tough annual grass, cereal rye, is planted extensively in the Wind Area of southern California to control soil blowing during winter months in grape vineyards. The surface soils of the Area are largely sands, low in readily available plant food. To determine the response of this protective grass to fertilizers, plot studies were started in the fall of 1947. One year's data are at hand bearing on the response of the grass to fertilizer and on the indirect effect of strong growth of the grass cover crop on the succeeding grape crop. These data are summarized in the following table. Nitrogen was applied as ammonium sulphate; phosphorus as treble superphosphate.

TABLE A

| Fertilizer | Dry Weight of Grass Tops Lbs. per acre | Weight of Wine Grapes Tons per acre |
|--------------------------------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------|
| CHECK (none) | 152 | 3.57 |
| NITROGEN ONLY 36 lbs. nitrogen per acre | 468 | 3.21 |
| PHOSPHORUS ONLY 75 lbs. P ₂ O ₅ per acre | 110 | 4.02 |
| NITROGEN AND PHOSPHORUS 36 lbs. nitrogen per acre 75 lbs. P ₂ O ₅ per acre | 895 | 4.23 |

Some of the trends to be noted in the data are:

1. The grass did not respond at all to applications of phosphorus alone.
2. The grass responded (a) moderately to applications of nitrogen alone and (b) strongly to applications of phosphorus and nitrogen.
3. There was no depression of grape yields on these plots for the season 1948, as a result of strong growth of cereal rye as winter cover crop.

Watkinsville, Georgia, B. H. Hendrickson, Project Supervisor.

1. Past Erosion Reduced Cropland Productivity for Many Years.

Based on average crop yields on Class II land, crops harvested on Class IV land by identical cropping practices were reduced because of past erosion during the 6-year period, 1943-48, as follows:

| | |
|--------------------|------------|
| Continuous cotton | 42 percent |
| Corn in rotation | 40 percent |
| Oats in rotation | 36 percent |
| Cotton in rotation | 34 percent |
| Vetch in rotation | 22 percent |

2. Conservation Cropping Practices Protected and Improved the Land.

All of the better close-growing covers, and the conservation rotations continued to maintain or increase erosion control and soil building ability, on well-terraced land, during 1948.

These progressive beneficial effects are due to the gradual increase in soil organic matter content and improvement in soil aggregation which result from the repeated use of good conservation rotations. There has been no indication, as yet, that the maximum benefits in this connection have been secured.

3. Conservation Rotations Increased Nitrogen Content of the Soil.

Analyses of soil samples collected before and after good conservation rotations had been grown on the land, showed consistent gains in content of nitrogen.

4. Conservation Paid Off in 1948.

Yields of principal crops trended sharply upwards during the good summer growing season of 1948, when they were produced in good protective rotations. Cotton yielded up to 1.7 bales per acre; hybrid corn 88 bushels per acre.

5. Conservation is Paying Off, Over a Term of Years.

During the 5-year period, 1944-48, continuous cotton (check) on Class II Land produced an average yield of 984 pounds per acre of seed cotton. A good rotation increased it 13 percent; a better one 20 percent.

During the same period, continuous cotton (check) on Class III Land produced an average yield of 894 pounds per acre of seed cotton. A fair rotation increased it 17 percent; a better one 22 percent; and the best one 24 percent or 35 percent, - depending on the amount of close-growing summer legume residue that was turned under ahead of cotton in the rotation.

The following slogan continued to prove true: "The more ground cover, the more legume residue, the larger the crop yields."

6. Protective Effects of Tillage.

Furrow planting of winter cover crops of oats and vetch, versus smooth surface drilling, again reduced winter erosion appreciably in 1948. All tillage was on the contour.

7. Production Effects of Tillage.

Land preparation tests with 4 tools, - ripper, disc harrow, disc tiller and disc plow continued to show little advantage, over any of the others, in terms of wheat or cotton yields produced in a good conservation rotation on Class III land.

8. Conservation Farming with Tractor Equipment.

The first year's experience by the tenant on the 100-acre conservation farm with mechanized equipment developed the following advantages:

1. Land preparation, planting and cultivating was completed more rapidly and thoroughly, and with less effort by the operator than in former years when a mule team was used;
2. Additional pasture was developed;
3. Off-the-farm tractor work was exchanged for combine hire;
4. And more time was available for the livestock enterprise.

9. Perennial Vegetation on Terraces - An Accepted Method.

Strips of sericea lespedeza established on the downhill side of steep cropland terraces continued to function well and prevented terrace breakage, in 1948. As a result of the long-standing satisfactory record of this method, the PMA of Georgia adopted it as a requirement for terracing on steep land in 1949.

10. Supplemental Irrigation Increased the Cotton Yield.

A 57 percent increase in cotton yield, and 39 percent in alfalfa hay yield for 1 cutting was secured during the good growing season of 1948, on trial areas receiving supplemental irrigation during dry spells. The cotton received 2 two-inch applications, the alfalfa but one.

11. A Kudzu-Covered Watershed Checked Flash Runoff.

A heavy ground cover of kudzu on the 19.2-acre watershed nearly eliminated runoff from rainstorms of short duration, during 1948, regardless

of their intensity. Large quantities of runoff were recorded from heavy rainfall which produced saturated soil conditions. All peak rates of runoff were low. There was little relationship between the short period, high rainfall rates and the maximum runoff rates in the rains of long duration.

12. Long-Season Grazing is Proving To Be Practical on Steep Eroded Hillside Land.

Summer grazing on sericea and on kudzu was supplemented by winter grazing of small grain, grasses and winter annual legumes grown as successive crops on the same land. Valuable additional grazing was secured during the fall, winter and early spring. Volunteering types of the winter crops, and perennial grasses that do not seriously compete with the summer growth of kudzu and of sericea, appear to be most satisfactory for the development of pastures of this type.

This method transforms poor, eroded, idle land into productive long-season pastures.

13. Flowable Grasslands - A New Development for the Southern Piedmont.

The tall fescue grasses, Kentucky #31 and Alta, showed real promise of adaptability on the better upland soils. In addition, large crops of valuable seed were produced by the 2-year-old stand of Kentucky fescue in 1948. These grasses are perennial, cool-weather growers which persist well the year around. Aside from their marked value for winter grazing, they offer much promise as a new grass base for highly protective pastures and crop rotations as well.

St. Anthony, Idaho, Hugh C. McKay, Project Supervisor. The field trials in Utah gave some very encouraging results. Every attempt at stubble mulch previously in this area had always resulted in a slight decrease in yield. The yields obtained from the field trials in 1948 show an average increase of 1.5 bu. per acre for the stubble mulch plots as compared to the checks. This further proves that stubble mulch tillage when properly handled will give equal to or greater yields than the common practice.

In the stubble mulch studies on the station, leaving the residue on the surface with the modified moldboard plow gave an increase of 7.4 bu. of wheat per acre as compared to turning the stubble down with the moldboard plow. Surface utilization also gave an increase of 2.8 bushels per acre as compared to mixing it with the surface soil with the one-way disk. The average yield for the past 9 years shows a 2 bushel advantage for the modified moldboard plow as compared to the moldboard or one-way disk.

A new factor entered the picture this year when all of the wheat samples for the past few years were analyzed for protein. It was

found that utilization of stubble decreases the protein about 1 percent. Also that the type of plowing affects the protein. Modified moldboard plowing caused a reduction of over 1 percent as compared to the moldboard. The application of 75# of Ammonium Sulphate fertilizer increased the protein content about 1 percent. The greatest reduction of protein was found in the 4000 lb. straw plot.

The soil loss data for 1948 were quite erratic but the stubble-burned plots still gave the highest average soil loss.

Moisture analysis in 1948 showed a definite decrease in the stubble burned plots for the one-way disk, modified moldboard and sweeps, for the moldboard and fall plow modified moldboard plows stubble burning showed an increase in moisture. The rotary subsoil plots did not show an increase in moisture, indicating that an increase in moisture from this practice can only be expected when it is done on slopes with run-off.

The protein analyses on the sweet clover treatment plots showed an increase of 3 to 5 percent protein in the first crop of wheat following legumes and a decrease in the second crop. This decrease was due to the large amount of stubble resulting from the first crop of wheat utilizing all the available nitrogen in its decomposition.

The soil conserving grass and legume rotation data showed an increase of 2-7 bushels in the first crop of wheat following legumes, 3-13 bu. in the second crop and 2 to 10 bushels in the third crop of wheat. The grass rotation again gave the highest yield for the first crop of wheat.

The protein analyses for the rotation plots using legumes and grasses showed an increase of from 2-5 percent in all plots except in the grass rotation, which has less protein.

Urbana, Illinois, Dr. E. L. Sauer, Project Supervisor.

Capital Costs and Benefits of Soil Conservation in Northeastern Illinois Slowly Permeable Soils Area.

Capital expenditures for conservation and related improvements were analyzed on 100 farms. For the years 1945-47 the average annual capital expenditures were \$3,210, or \$12 an acre. Of the \$12 an acre, \$1.65 was spent for land improvements, 96 cents for buildings, \$5.85 for livestock, and \$3.54 for machinery.

The farmers of this area were asked what their farms needed in order to develop a good conservation program. Standard costs were used to reduce estimates of materials to dollars and cents. These costs averaged \$6,600, or approximately \$24 an acre. They included needed

applications of limestone and phosphate, drainage, and conservation structures, as well as livestock, buildings, and machinery needed to use increased quantities of roughages. The estimates included as many non-land improvement items (livestock, buildings, machinery) as land improvement. Estimated conservation needs averaged somewhat more on the tenant-operated farms than on the owner-operated farms.

The conservation plans worked out by soil conservation technicians and farm advisers with these farmers were then analyzed to determine the costs of establishing conservation programs in this area. The land improvements alone amounted to \$23 an acre. The plans showed the need for much larger applications of limestone, phosphate, potash, and mixed fertilizers than the farmers estimated. The requirements outlined in the plans are based on soil tests and agricultural experiment station recommendations for maintaining a high level of production. The results in this area indicate that farmers tend to apply too little limestone and other mineral fertilizers to maintain the good stands and yields of legumes basic to any program of soil improvement and conservation.

The farmers thought they needed more tiling and other structures than was recommended by soil conservation technicians and farm advisers. The plans emphasized grass waterways, sod flumes, terraces, and open ditches. If the \$12 an acre estimated to be needed for buildings, livestock, and machinery to implement a conservation program were added to the \$23 for land improvements, the total cost of a conservation program would approximate \$35 an acre, or \$8,400 for a 240-acre farm.

Farmers and landowners will question the outlay of \$35 an acre for conservation unless they sincerely believe it will pay. For the three years 1945-47, the annual income of 40 high-conservation farms in this area averaged \$10.63 an acre more than that of 40 low-conservation farms. At the present level of prices, the capital outlay for conservation could be repaid over a short period of years.

Immediate Conservation Benefits in Cash Grain Area. During the three-year period 1945-47, 18 farms in McLean County (on which conservation plans were started in 1945 or since) produced grain equal in dollars and cents to that produced on comparable farms not following conservation plans. In addition they had over twice as large an acreage of legume hay and pasture and were building up their land for crop production in subsequent years. They also had lower total labor, power, and machinery operating costs because of a smaller acreage of cash crops. These results show that even in the cash-grain area conservation plans will yield dividends on a short-run basis.

Livestock and Conservation. More livestock are needed on many farms to use the increased legumes and grasses resulting from a conservation program. On farms where grain acreages must be materially reduced in order to use the land according to its capabilities, increases in crop

yields may not offset reductions in acreages. But in most cases the increased returns from livestock bring higher net incomes. In addition, this system of farming helps to conserve soil and water and improve fertility. Modest improvements for livestock production may be a pertinent part of a conservation program.

In each area studied, the high-conservation farms had higher returns per \$100 worth of feed fed and produced more pounds of milk and meat per acre than the low-conservation farms. In part, if not entirely, these higher returns and production were due to the larger quantities of better-quality roughage produced. Higher crop yields reflect the effect of added minerals, legumes and grasses, and more manure.

Tenure and Conservation.

In our studies the part-owner farms had the highest proportion of tillage land in corn and soybeans and the owner farms the lowest. But the owner farms had more tillable land in hay and pasture. Annual per acre expenditures for conservation, land improvements, and buildings were highest on owner-operated farms and lowest on tenant-operated farms. The amount of livestock and livestock production per farm was considerably higher on the owner-operated farms than on the other two groups.

Tenure problems keep some landowners from adopting conservation practices. In areas with a high proportion of tenancy, how to divide increased costs and increased returns between landowner and tenant is a real problem. Another problem is how to use the increased quantities and roughages produced under a conservation plan. If livestock numbers are to be increased and grain acreage reduced on rented farms, livestock-share leases may have to replace some crop-share-cash leases.

Reservoir Watershed Studies.

Much of the silting in the six Illinois reservoir watersheds studied can be traced to the soil-depletive type of farming and the lack of application of conservation practices. Adequate soil and water conservation and erosion control measures are needed, not only to protect the reservoirs from silt damage but to prevent the farmland from being irreparably damaged.

Summary of Economic Research Findings to Date.

Our economic studies of conservation to date have not given us all of the answers to the problem. But they have pointed out significant relationships and have helped us to lay the groundwork for further studies in the field. From the standpoint of helping the individual farmer and the agricultural worker, we believe they point to the following significant facts:

The farms that scored highest in conservation practices followed a complete plan, including (1) testing and treating the soil, (2) using the land according to its capabilities, (3) using rotations with ample acreages of deep-rooted legumes, and (4) using proper water disposal practices, such as grass waterways, contouring, strip cropping, terracing, tile and open-ditch drainage where needed. These farms also tend to utilize forage crops through livestock.

Conservation plans do not necessarily increase earnings immediately, because considerable effort and money must usually be expended before positive results are achieved. The long-time benefits of conservation, however, are certain. Over a long-term period, conservation farms that have spent more money for soil and related improvements have more land in legumes and grasses, have higher crop yields, produce more and better-quality hay and pasture, feed more livestock, have higher livestock production and returns, and secure larger net farm incomes.

In all comparisons the high-conservation farms had higher livestock efficiency as measured by "returns per \$100 of feed fed." Does this fact reflect better livestock management or better feed? It can be argued, although our studies have not proved it, that better-quality feed supplies--grain, hay, and pasture--explain the greater efficiency. In getting progress in agriculture--and conservation farming represents progress--it is important to get farmers to adopt systems which, in the hands of the average operator, lead to progress. Systems that conserve soil and water bring better crop yields, make the land easier to work, and apparently provide better feed supplies, one of the fundamentals in more efficient livestock production.

Money spent on conservation is a sound investment. In addition to improving both present and future productivity, conservation practices usually increase the net income in one to four years, depending on the extent of needs. The returns provide a safe basis for establishing credit to put the conservation program into effect. Although the net income may be reduced temporarily, the productive value of the land increases immediately, protecting the financial position of the landowner until the long-time benefits of conservation can accrue. With our own as well as the world's population increasing, investments in improving soil fertility, conserving soil and water, and controlling erosion should pay high dividends.

Urbana, Illinois, Dr. C. A. Van Doren, Project Supervisor.

I. Contour Farming Study (Urbana, Illinois)

Since 1945 the contour farming plots have been farmed to a sequence of corn and soybeans. Soil losses from the contoured corn plot have averaged 1.6 tons per acre per year which is 47 percent of the losses from the non-contoured plot. In a corn-oats rotation from 1941-44, the soil losses from the contoured plot were 62 percent of the losses from those farmed up and down. Soybeans have been much more effective

than corn in reducing soil losses when planted on the contour. Soil losses from the contoured soybean plots averaged 0.7 tons per acre per year which is only 25 percent of the average annual loss from the non-contoured plot of 2.9 tons per acre.

Effectiveness of contouring with three crops in two different rotations is shown below:

| Crop | Period | Soil Loss | | Effectiveness Ratio = $\frac{\text{Contour}}{\text{Non-Contour}}$ |
|--------------|---------|-----------|-------------|-------------------------------------------------------------------|
| | | Contour | Non-Contour | |
| Oats (1) | 1941-44 | 1003 | 1643 | 0.61 |
| Corn (1) | 1941-44 | 5025 | 8092 | 0.62 |
| Soybeans (2) | 1945-48 | 1436 | 5758 | 0.25 |
| Corn (2) | 1945-48 | 3272 | 7031 | 0.47 |

- (1) Corn-oats sequence of crops
- (2) Corn-soybeans sequence of crops

Contour farming was unusually effective in 1948 as most of the erosive storms occurred after late June when contour ridges were developed for protection. Soil losses from the contoured plot in corn were only 23 percent of the losses from the non-contoured plot, while losses from contoured soybean plot were only 17 percent of the losses from the non-contoured plot.

In 1948 contoured corn outyielded non-contoured corn by 7.5 bushels per acre. Contoured soybeans outyielded non-contoured soybeans by 2.7 bushels per acre.

II. Drainage and Percolation Studies in Northeastern Illinois.

In 1948 tile drainage efficiency was measured by wells spaced in a line perpendicular to existing tile lines. Drawdown curves were prepared representing Drummer silty clay loam, Elliott silt loam, Clarence silt loam, Rowe silty clay, and Bryce silty clay loam. 1948 was a good year to secure data on drainage as ground water was recharged early in winter and rains were plentiful.

These studies were continued and expanded in 1949, although the season to date has been too dry to secure much data.

The following tentative conclusions can be made from the drainage and percolation studies in northeastern Illinois.

1. Surface water in all ponded areas must be removed by shallow channels or tile with surface inlets.
2. Benefits from tiling are doubtful on Rowe, Clarence, and even Bryce.

3. The inconsistencies in data indicate that these soils must be sampled in different sections of the area.
4. The effects of cropping on drainage must be studied in a well planned experiment (work tentatively approved).
5. In recent years farmers are apparently annually wasting huge sums of money for tiling fields where benefits are highly questionable.

III. Availability of Moisture - Important Phase of Pasture Irrigation Study (Dixon Springs, Illinois)

Two adjacent five-acre tracts were treated and seeded in the fall of 1947 and spring of 1948 to a ladino clover-grass mixture. One five-acre tract received no supplemental irrigation. One-half of the second five-acre tract received six one-inch irrigations, and the other half, six two-inch irrigations during July, August, and September in 1948. The Illinois Agricultural Experiment Station is responsible for water application, grazing, and yield determinations. (1)

Electrical resistance blocks were installed to determine when to irrigate and also to determine the effectiveness of use of supplemental water in increasing forage production. Blocks were installed at four depths in the upper 12 inches at four locations on each plot. The percentage of the available moisture remaining in the soil before and after two of the six irrigations is shown in the following table:

Percent of Available Moisture Remaining in the Soil Before and After Selected Irrigations - 1948 (1)

| | Before : 7/31 | After : 8/6 | Before : 8/17 | After : 8/23 | Seasonal Average |
|-----------------------------|------------------|----------------|------------------|-----------------|---------------------|
| Non-irrigated | 10 | 4 | 0 | 0 | 17 |
| Irrigated (6 times, 1"app.) | 6 | 32 | 26 | 52 | 34 |
| Irrigated (6 times, 2"app.) | 28 | 49 | 50 | 59 | 48 |

(1) Tentative calibrations indicate this soil would contain 29% moisture (on dryweight basis) at field capacity and 11% at permanent wilting. Thus 29 - 11 leaves 18% available to plants in saturated soil. Figures in table represent percentage of this available moisture in soil on dates indicated. This report involves only discussion of moisture relationships as influenced by irrigation.

A marked increase in the amount of moisture available to forage in the surface 12 inches after irrigation is indicated for both one and two inch applications. During the month of August only slight amounts of available moisture were present in the surface 12 inches of soil on the non-irrigated field. For a three month period the soil where six one-inch irrigations were applied contained 34 percent of the available moisture, and the soil receiving six two-inch irrigations contained 48 percent of the total possible available moisture. It is apparent that for maximum growth with good treatment on these soils, even with normal rainfall during July, August, and September, an additional supply of water is needed. The application of six one-inch

irrigations did not give maximum growth, even though it made an average of over five inches of water per month.

IV. Runoff and Yields Influenced by Grazing and Fertilization (Dixon Springs, Illinois)

One replicate in the soil treatment and grazing management study received 1000 pounds of 8-8-8 fertilizer in March on the previously treated plots. The previously untreated plots received 400 pounds of ammonium sulphate. Both treated and untreated plots received 150 pounds of ammonium sulphate after each 4 - 6 weeks grazing period. Heavy fertilization is being tried in an effort to reduce weed content and prolong expensive reseeding.

Runoff from moderately grazed plots was only slightly more than one-half the runoff from severely grazed areas with comparable soil treatment. Soil losses were not measured; however, previous measurements have proved that losses are only slight on established pastures.

After fertilization in 1948 the plots produced the largest amount of forage for sheep production that has been produced on the plots since establishment in 1939. The treated, moderately grazed plots produced an annual mutton yield of 185 pounds from 1938-47. In 1948 these plots produced 484 pounds per acre. Comparable increases were produced on all plots. Although it is too early to determine the ultimate effect of this program on weed population, the broomsedge density appears to be reduced on the well treated plots.

V. Supplementary and Exploratory Studies.

Detachability of Soil - Splash cups were exposed to natural rains during eight storm periods in 1948. The amount of splash from unprotected Flanagan silt loam (Urbana plots) and Grantsburg silt loam (Dixon Springs) was compared to splash from standard sand. The average D_2 factor (ratio of splash from sand divided by splash from soil in grams) for Flanagan was 0.41 and for Grantsburg 0.32. Although Grantsburg silt loam is finely dispersed and low in organic matter the particles seem to be cemented well together. In 1949 other soils from northeastern Illinois are being exposed.

Earthworm Counts - Earthworm population and counts seem to be influenced by soil treatment and grazing management. Counts made in April 1948 showed a greater number of worms on untreated plots; however, the average live weight of worms was 0.67 grams on the treated, moderately grazed plots as contrasted to 0.24 grams on the untreated plots. The average live weight of worms was reduced from 0.67 grams on the treated, moderately grazed plots to 0.26 grams on severely grazed treated plots.

Organic Matter Increases - The treated, moderately grazed plots had the greatest increase in organic matter over an eleven year period

ending in 1948. Soil samples were collected in 1937 and again in 1948. Decreases which occurred on some severely grazed and on the untreated plots are not large; which indicates that organic matter can be maintained on most pasture land regardless of treatment.

Ames, Iowa, G. M. Browning, Project Supervisor.

Value of Contour Cultivation.

On 12 fields in Crawford County in 1948, contoured corn outyielded adjacent areas planted up-and-down hill by 7.4 bushels per acre. The average increase in corn yields on 190 farmer fields representing a wide range in soils, slopes and climatic conditions during the past year was 9.2 bushels per acre. The average increase from contouring soybeans was 2.7 bushels per acre and for oats 5.4 bushels per acre. From May 15 through December 31, 1948, when soil and water loss measurements were made on Ida silt loam soil with 14% slope, surface planted corn lost 38.3 tons of soil per acre when planted up-and-down hill. Adjacent areas with similar management practices but planted on the contour lost only 7.2 tons per acre. On contoured listed corn following a corn-oats-meadow-meadow rotation soil loss was 3.8 tons per acre in contrast with a loss of 8.1 tons per acre from contour listed corn in a corn-oats-sweet clover rotation.

Effect of Tillage Practices in Western Iowa.

As an average of 5 years' results on 43 fields in western Iowa, tillage practices have not caused a marked difference in yield of corn. As an average of all fields, representing 5 important soil types in western Iowa, yield of corn from plowed plots was 71.4 bushels per acre, hard-ground listed 68.9 and subsurface tilled 67.4. On the same fields the application of commercial fertilizer at the rate of 125#/A of 4-16-0 with a planter attachment plus 100#/A 33-0-0 broadcast at planting time increased the yield of corn on the plowed plots by 2.6 bushels per acre, hard-ground listed by 5.1 bushels per acre and subsurface tilled by 4.3 bushels per acre. On two fields of Marshall silt loam in 1948, the yield of corn on land plowed with the TNT plow was 10 bushels per acre higher than adjacent areas plowed with the conventional moldboard plow. The differences in yield in 1948 were considerably larger than the 4.2 bushels per acre average increase in yield of the TNT plow over the moldboard plow on six fields during the period 1946-48.

Influence of Rotations on Soil and Water Losses and on Yields.

The previous cropping system has had a marked effect on runoff and erosion and crop yields. Soil loss from corn growing continuously over a period of years has averaged about twice as much from corn grown in a rotation of corn-oats-meadow. Soil loss from oats grown in the same rotation has averaged about one-half that from corn while the loss

from the meadow crop has been negligible. On an area that has been cropped continuously to corn since 1931 the yield in 1948 was 17.7 bushels per acre. Yield of corn grown in a corn-oats meadow rotation during the same period was 100.6 bushels per acre. After two rounds of a corn-oats-meadow rotation following 11 years of continuous corn the yield was 65.3 bushels per acre. This yield is 47.6 bushels higher than from continuous corn but is still 35.3 bushels below the yield obtained on areas in a corn-oats-meadow rotation throughout the entire period.

Use of Terraces on Ida Silt Loam Soil.

Terraces constructed on an Ida silt loam with slopes ranging from 12-20%, with spacing of 1 1/4, 1 1/2, 1 3/4 and two times normal spacings, have operated satisfactorily during the last two cropping seasons. These areas are farmed in a corn-oats-meadow-meadow rotation and listed on the contour. These studies are being made to determine the various vegetative and mechanical practices that may be necessary in controlling runoff and erosion on the steep loess soils of western Iowa which are now being cropped with about 50% of the cropping acreage in intertilled crops.

Experiments with Cover Crops.

Stands of cover crops on 13 fields at 7 locations in the state in 1948 were poor because of unfavorable moisture and temperature conditions. These are a continuation of studies that have been carried on over a period of years which indicate that, on the average, satisfactory stands of cover crops can be obtained in about three out of four years. In the north and eastern part of the state where rainfall conditions are more favorable, satisfactory stands are obtained in a higher percentage of the years.

Effect of Grasses and Legumes on Soil Structure.

Cropping systems that contain grass and legume meadow crops regularly in the cropping system have been found to have a higher percentage of large sized aggregates than fields cropped heavier to intertilled crops with only an occasional meadow crop. Soil and water losses have been much lower on the soils that contain a higher percentage of large aggregate which resist the beating action of raindrops. By mixing equal portions of the silty surface and heavy clay subsoil of the Edina soil, and after applying organic matter as alfalfa or sweet clover, the percentage of aggregates 0.25 mm was more than twice that from the untreated surface soil. This is part of a study attempting to determine the possibilities of improving the very poor physical conditions of the Edina surface soil. Aggregation studies on surface samples of Marshall, Clarion and Belinda soils show that the effects of cropping systems and season of

the year have a large influence on the size, distribution and stability of soil aggregates. Areas that had meadows regularly in the cropping system contained a higher percentage of large sized aggregates which were from two to five times as stable in shaking as samples from areas cropped continuously to corn. Decreasing the moisture content at sampling time increased the percentage of aggregates 1.0 mm. This was true regardless of whether the usual method of fractionation was used or whether the samples were given a pre-shaking treatment before fractionation.

Level Terraces on Loess Soils of Western Iowa.

Level terraces are working satisfactorily on the deep permeable loess soils of western Iowa. Observation of stands in the terrace channel and of overtopping have been made on level terraces constructed on soils where the loess material extends to a depth of from 20-50 inches. In general it is believed that level terraces cannot be safely recommended unless the permeable loess layer is at least 50 inches deep, although local conditions have been found where level terraces are working satisfactorily where the loess is only 20 or 30 inches deep. Studies of permeability and other physical properties of soil profiles indicate the immediate surface as well as the profile to a depth of 40-50 inches are critical in determining the satisfactory operation of level terraces. As the permeability of the surface is maintained through good cropping systems and with 50 inches of permeable layer below, level terraces are generally working.

Tile Spacing Experiments on Edina Soils.

A depth and spacing tile experiment has been started on the Edina soil in southeastern Iowa. Water table readings are being made at regular intervals throughout the growing season. In addition, water table readings are also being made on 6 farmer fields where tile has been installed on Edina, Haig and Taintor soils. Past experience indicates that it is not economically feasible to drain the Edina soils. The Taintor soils are more permeable and tile generally operate satisfactorily in the soil. The Haig soil is less permeable than the Taintor but more permeable than the Edina. Water table readings, permeability studies and yield of crops at different distances from these tile should furnish valuable information for recommendations of tile installations on large areas of soil in southeastern Iowa. Waterstage recorders have been installed for determining runoff from treated and untreated watersheds in the Little Sioux Flood Control Project. Installations are being made of areas representing the steep bluff area near the Missouri River with slopes ranging from 18-30%, on the less steep areas ranging in slopes from 10-18% and on the flatter areas in the head waters of the watershed ranging in slopes from 3-8%. Specific information on runoff from soils of this type and the effect of land treatments such as terracing,

contouring and better land use is not available. Information of this type is needed for the most economical design of detention reservoirs and other gully control measures now being constructed in the Little Sioux Watershed.

Manhattan, Kansas, Austin W. Zingg, Project Supervisor. The project is one of a regional nature designed to carry out fundamental research on the movement of soil by wind in the High Plains area.

It is cooperative between the Kansas Agricultural Experiment Station and the Research Division of the Soil Conservation Service. Work is centered in the Department of Agronomy at Kansas State College, Manhattan, Kansas.

The project supervisor reported to the Manhattan location on October 27, 1947. Active work on the problem was started by the first of the 1948 calendar year.

An office and two laboratories were developed during the year. One laboratory houses a soil blowing tunnel, and storage space for soils and equipment essential to preparing them for tunnel tests. The second is for physico-chemical analysis of soils as related to their erodibility by wind.

The laboratory tunnel has a potential working section 56 feet in length. It is comprised of a duct 3-feet square. The wind-making equipment consists of a 31 H.P. gasoline power unit which drives a 3-foot axial type commercial ventilating fan. The flow of air to the fan is regulated by adjustable inlet vanes. Micro-control of velocities ranging to 40 miles per hour is obtained readily. The motor and fan are mounted on a rigid steel framework which is mounted on a concrete base for laboratory use. It is also designed for conversion into a trailer for future field use. The development of air flow characteristics suitable for controlled experiments on soil erodibility was completed during the year. Experiments involving tunnel tests of soils were initiated in the late fall of 1948.

Development of the soil analyses laboratory proceeded simultaneously with that of the wind tunnel laboratory. Assembled apparatus are on hand to perform essential physical and chemical analyses. Research on the characteristics of 9 major soil types from the High Plains area was completed in part. Experiments designed to modify soil characteristics by mineral and organic matter additions were initiated. A search for emulsifying agents and cementing materials having possibilities of application to the soil to reduce its susceptibility to blowing was also carried out.

A study of the 74-year record of wind movement, precipitation, and temperature at Dodge City, Kansas, was made with a view to determining

the frequency of combinations of climatic factors which influence soil blowing. It was found that the occurrence of wind velocities of various magnitudes was amenable to estimation by probability methods. Wind storms were also found to have characteristic patterns relating to intensity, distribution and duration.

Three articles dealing with various phases of the investigations were approved for publication in technical journals during the year.

Orono, Maine, J. W. Slosser, Project Supervisor. Increased conservation of water and soil by interceptions between diversions on steep slopes increased potato yields by 17.9 percent or 19 barrels per acre.

The use of interceptions, green manure and good tillage practices quickly improve run down soil physically and result in much larger yields and an easier working soil.

Crop land terraces conserve moisture, soil, and fertilizer, resulting in greater yields at less cost. In eight years on the research farm, terraces, good land practices, and green manure have raised the yields from 74 barrels to 175 barrels - an increase of over 100 percent.

Land farmed to continuous potatoes becomes deficient in organic matter and so may require the use of green manure crops to maintain a proper level of organic residues. The addition of extra nitrogen may be necessary to get rapid decomposition of the cover crop when turned under.

Potato Harvester.

The project harvester is a simple practicable solution to the harvesting problem and except for minor refinements, is considered ready for manufacture.

Studies indicate that the disc plow merits wider use in the conservation program for the Northeast.

The project spray system is greatly effective in obtaining full coverage of spray materials or plant killers. It requires publicity to convince farmers a better spray job is needed before general adoption of the principle is effected.

Beltsville, Maryland, C. S. Britt, Project Supervisor.

Tobacco Research Tests.

1. Ridge Rows Compared with Flat Rows: Ridge and flat culture of tobacco was compared on nine sets of plots with all rows on about 1% grade. The ridged tobacco was larger and grew better throughout the season than the flat cultivated tobacco. Two heavy rains occurred approximately thirty days after planting and this excess water caused the flat cultivated tobacco to turn yellow and stop

growth. Roots dug from the plots showed that root growth in the flat areas was limited to the top few inches of soil while the tobacco roots in the ridged areas penetrated to considerably greater depth. Six sets of the plots have been stripped and the ridged tobacco outyielded the flat tobacco by 200 lbs. per acre on these plots. Values will not be known until all the tobacco is stripped and evaluated.

2. Late Turning of Winter Covers Gives Heavy Organic Residues: Late turning of winter cover crops on tobacco land was compared with early or "normal" turning of winter cover crops. The late turning gave from 1 1/2 to 5 tons more dry top growth per acre than the early turning. This extra month of growth of the winter covers creates some difficult management problems. However, the increased tobacco yields and improved soil tilth and erosion control more than compensate for these problems. In 1946 (the latest yield figures available) the late-turning of the small-grain vetch mixtures increased the tobacco yield by about 300 lbs. per acre which was worth almost \$100 per acre.

Runoff and soil loss tests by T. L. Copley and C. S. Britt in cooperation with the Auburn, Alabama, Research Project, showed that two tons of coarse organic matter mixed with the top soil reduced the soil loss by 58% on a 1% slope; 68% on a 5% slope and 75% on a 10% slope. The above figures are from the Auburn Tilt Plots with artificial rainfall of 3.5 inches per hour for 45 minutes.

Ridge Row Field Trials:

The two farmers using ridge rows on slight grade with their tobacco obtained outstanding results during the past summer. Unusually heavy rains during June and August caused severe erosion and leaching damage in most tobacco fields in Southern Maryland.

Mr. Calvert Norfolk, Owings, Maryland, reported that his field of ridged tobacco was better than any of his five fields of tobacco that were planted flat. The ridged tobacco made more uniform and faster growth than any other field of tobacco he grew. The ridged field kept all the topsoil in place while the heavy storms caused severe erosion damage on all his flat planted fields.

Mr. H. W. Townshend, Mitchellville, Maryland, reports that his ridge rows, terraces, and waterways did an excellent job of keeping his soil in place during the past summer. Farmers in his neighborhood generally suffered rather severe damage to their land and tobacco crops by erosion, leaching, and drowning.

County agents, farmers and technicians from the tobacco area visited Mr. Townshend's farm in August, and said that the tobacco was larger

and more uniform than any field of tobacco they had seen all year. Mr. Townshend filled all his tobacco barns with only a little more than half his usual acreage.

The State Soil Conservation Committee has asked that these field trials be expanded as rapidly as time and funds permit.

College Park, Maryland, Dr. Roy C. Dawson, Project Supervisor.

The distribution of nitrate nitrogen within the top five feet of ridge rows of a sandy soil used for growing tobacco at the Beltsville, Maryland, Research Center has been followed throughout the tobacco growing season for 1948. The plots were maintained free of vegetation. The season was an abnormally wet one. An alfalfa-bromegrass mixture alone, with wheat straw, and with ammonium sulphate, was plowed under on April 12 and May 27.

Because of uncontrolled variability encountered within the first and third foot depths, no definite conclusions could be made as to the effects on soil nitrates of the various factors studied. The greatest amount of significance was found in data obtained within the second foot of soil or within the 0-5 foot profile.

Seasonal variations in the nitrate content of both the second foot and the 0-5 foot depths were found to be highly significant. Nitrates were lowest in June and increased to a maximum in August after which a decrease followed.

The addition of wheat straw at the rate of 2 tons per acre significantly reduced the nitrate nitrogen content of the soil, both at the second and 0-5 foot depths, as compared to the addition of ammonium sulphate at the rate of 40 lbs. of nitrogen per acre.

Early plowing (April 12) of alfalfa-bromegrass alone, resulted in a higher mean nitrate nitrogen value for the second and 0-5 foot depths than late plowing (May 27). Date of plowing had no significant effect on the mean nitrate nitrogen content where the alfalfa-bromegrass was supplemented with wheat straw or ammonium sulphate.

In June the nitrate content of the second foot of soil had a tendency to be greater where residues were plowed early (April 12) than where they were plowed late (May 27). In October significantly greater amounts of nitrates were found under late plowing (May 27). In July, August and September the results were variable.

Although the nitrate content of the fourth and fifth foot depths of soil was low at all times there was a progressive increase, because of leaching, throughout the season.

The extent of decomposition during the first week of incubation at 25°C and 30°C of various plant materials incorporated in a sandy soil of pH 4.4 and at 2/3 its moisture holding capacity was determined. The effects of the decomposing plant materials on soil nitrates and pH and on the loss of gaseous ammonia were also studied.

Alfalfa and tobacco stalks were the most easily decomposed, followed by ragweed and tobacco roots. Corn cobs and stickweed were the most resistant to decomposition. Temperature effect (25°C vs 30°C) was not significant.

Soil nitrates were depressed by corn cobs, stickweed, ragweed and tobacco roots, but not by alfalfa or tobacco stalks.

College Park, Maryland, Dr. Henry Hopp, Project Supervisor. The productivity of loam, silt loam, and clay soils tested proved to be markedly increased by earthworms. They improve soil structure during the fall, winter, and spring; and the nutritional qualities of the soil during the summer. The amount that yields increase varies with the soil, depending on its original structural condition; and with the crop, depending on its tolerance to unfavorable soil conditions.

Over a wide area in the humid section of the country, from Maryland to Wisconsin, the earthworm population for typical agricultural soils where suitable conditions were maintained was between 10 and 30 individuals per square foot to the plow depth. These populations are sufficient to work over and improve a significant quantity of soil annually.

Infiltration, runoff, and erosion losses in control plots are closely associated with the earthworm population. In experiments, the favorable infiltration generally attributed to sod and mulch has been found in our tests to be due actually to the earthworms.

Under continuous clean cultivation, the earthworm population is seriously reduced. In the areas tested this reduction occurs during the winter and is due to an upset in the normal ecological balances in the soil. The reduction in earthworms during the winter is associated with a marked deterioration of soil structure.

A method for maintaining the earthworms on clean-cultivated land has been developed, based on protection of the soil surface in the late fall with a protective cover of mulch, crop residues, or sod. In certain soils, the treatment must be supplemented by lime and fertilizer to supply the nutrient requirements for earthworms. This treatment results in a great improvement of soil structure during the winter.

This research shows a new way of maintaining and conserving soil even when it is tilled frequently, and makes it possible to grow tilled crops more frequently than has been possible heretofore.

College Park, Maryland, Clarence S. Slater, Project Supervisor.

There have been three outstanding developments in connection with this year's work.

The first comes from the earthworm studies of Hopp and Slater. It has been found that earthworms and other forms of life that burrow in the soil are enormously effective in promoting rapid rates of infiltration. The data on this point are so conclusive that the promotion of a healthy macro-life in the soil must be given important consideration in problems relating to runoff and water conservation.

The second development relates to the measurement of soil permeability. Prior to the present time, soil survey classifications of permeability were merely relative, and were not related to any definite rates of water transmission. As a result of work we have done, the descriptive classification has been associated with quantitative expressions of permeability. The application of this development will promote uniformity in, and increase the value of, conservation survey evaluations of permeability.

The third development stems from the years spent by the writer of this report in soil physics research. The results of many experiments and much study were condensed in the paper, *The Flow of Water Through Soils*. Basic principles were presented with a minimum of mathematical treatment. There has been a strong and continuing demand for reprints of this paper. This shows that the fundamental concepts that were presented are needed by many workers.

Amherst, Massachusetts, Dr. Karol J. Kucinski, Project Supervisor.
A Survey of Erosion Problems Arising from Changes in Soil Use.

The commercial growing of potatoes in the western foothills and plateaus of Massachusetts has become well established during the past few years. Old sod and pasture lands, which have not been plowed for as many as thirty years, are now being cleared and put into potato production. Since the potato fields are rather large areas located on sloping hillsides, where the season does not permit the use of winter cover crops, considerable soil erosion has taken place. Periodic analysis of the soil taken from selected areas shows that in nearly all cases the organic matter content has decreased more than 50 percent from what it was five or six years ago. The farmers realize that their soils are deteriorating rapidly, and are calling on the Soil Conservation Service "Operations" for technical aid in solving their problems of erosion and soil depletion. Contour planting, terracing, and rotation with green manure crops are the control measures recommended.

The Investigation of Beach Grass.

The native or American beach grass (*Ammophila breviligulata*) found commonly on Cape Cod has been used successfully in the stabilization

of beach areas and coastal sand dunes. A heavy type of transplanting machine which has been developed recently is capable of planting about six acres a day. The use of this machine has made it economically feasible to transplant beach grass and has created a demand for large quantities of transplanting stock. There are some indication that fertilization of natural beach grass will tend to increase the stands and thus provide more and better propagating stock per given area.

Studies are in progress to determine what response beach grass will make to fertilization and liming, in the natural state and after it has been transplanted.

Investigations with Various Winter Cover Crops for Onion and Potato Fields in the Connecticut River Valley.

The date and rate of seeding and kind of cover crop used depend somewhat on the preceding and succeeding crop. For several years such crops as winter rye, barley, oats, buckwheat, domestic rye grass, and Italian rye grass have been seeded at weekly intervals from the beginning of September through the last week in November. Winter rye, oats, and barley produced excellent cover when they were sown in September and early October; fair to medium cover when seeded from middle to late October; and poor cover when seeded during November, especially during the last week of November, when growth was considered unsatisfactory. Not very much stooling resulted when these crops were seeded after the middle of October. Italian or domestic rye grass and buckwheat do well when seeded in early September. Rye grass, when planted early, produced a thick mass of fine roots, which may be superior to the coarse roots of the cereal plants for the prevention of water erosion. Some rye grass may survive mild winters, and this should be taken into consideration if seedings are made in fields to be used for certain crops like onions where it is not the custom to plow in the spring. Barley and oats, which winterkill yet produce a desirable protective mat cover, may be used in onions and other small vegetable fields. The mat thus produced can be easily disked and will not interfere with the preparation of the field in the early spring. Buckwheat can be used as a green manure crop, catch crop, or cover crop, but is not satisfactory as a winter cover crop. It is killed by the first light frost, and the mat produced on the soil surface is not a sufficient protection against erosion.

The rate of seeding for oats, winter rye, and barley is 1 1/2 to 2 bushels per acre, and the large rye should be used if seeding is made during October. For Italian or domestic rye grass, when used as cover crops, 25 pounds per acre has been found to be a desirable rate of seeding, and for buckwheat about 35 to 40 pounds.

Use of Snow Fencing in Controlling Wind Erosion.

Farmers in the Connecticut Valley have the problem of protecting their soils and crops from wind damage. The winds which occur during early spring result in losses of soil, seed, fertilizer, and young crops. This damage usually occurs at particular areas on a farm, called

"blowouts." To control these local "blowout" spots temporarily until the crop has established itself, some form of windbreak may be used. Trials have shown that snow fencing is satisfactory for this purpose. The cumbersome guy-wires generally used in connection with the fencing for protection against snow drifting are not necessary when the fencing is used for wind erosion control. Old iron pipes or wooden stakes 4-1/2 to 5 feet long, driven 18 inches into the ground and spaced a rod apart, will hold the 4-foot-high lath fencing throughout the entire season. If the fencing is placed on the windward edge of the "blowout" at right angles to the prevailing winds and the crop rows are placed parallel to the fencing, very little loss of tillable area or inconvenience in operation of farm machinery will be experienced. One fence row is usually sufficient to control "blowouts" of the size commonly found in this section.

State College, Mississippi, T. N. Jones, Project Supervisor. The total rainfall for 1948 was 58.54 inches, which was 7.78 inches above the past sixty-year average. February was above normal by 3.10 inches, May was low with 3.00 inch shortage, September high by 4.34 inches and October short by 2.16 inches. Although the overages, shortages and annual rainfall are significant the rains were not of an outstanding detrimental type so far as soil erosion is concerned. Winter cover crops continue to show great savings in soil loss, as well as increased yields over no cover crop.

The soil and water loss on a bare plot 1/40 acre in size on a 9 percent slope was 210,466 pounds and 2,948.8 cubic feet respectively per acre, as compared to 407.85 cubic feet per acre and no soil loss on sod plot of same size and slope.

Field tests in destroying hardpans gave some most encouraging results. The yield of seed cotton was increased 30 percent by use of special tillage equipment in seedbed preparation. The wholesale trend toward complete mechanization has brought the possibility of forming hardpans very strongly into the picture. Certain practices, such as continuous cropping to cotton with very little seedbed preparation and no legumes, on certain soil types will not continue to produce good yields. Complete mechanization demands a more complete understanding and carrying out of better farm management policies.

The preliminary work on field plots to produce residues and on management of such residues for soil saving and yield maintenance indicate that this work has great possibilities. The equipment to handle such a program is of most importance and several ideas are being worked on at the present time which it is hoped will enable the producing and maintaining residue on top of the soil, as well as, hold the yield on the same level as present equipment and management.

Columbia, Missouri, Dwight D. Smith, Project Supervisor. The year 1948 was marked by favorable weather, moderate erosion, and high crop yields. The findings emphasized that high crop yields result from a combination of high fertility, a soil physical condition permitting free movement of air and water, and favorable weather. High fertility and the desirable soil physical condition can be supplied when lacking, by use of fertilizer and the growing of grasses and deep rooted legumes in the rotation—both indispensable for conservation farming on soils naturally deficient in these two features.

The results of studies on the effect of cropping on soil conservation, with suggestions for their application to the soils of Missouri, were compiled at the request of the Missouri Agricultural Experiment Station and published as their bulletin No. 518, "Cropping Systems for Soil Conservation."

The following is a brief summary of work during 1948 by the Soil Conservation Service Research Unit at Columbia, Missouri.

Allowable Soil Loss.

Aside from the national aspects—saving surface soil for farming in future generations, prevention of stream and reservoir siltation, etc.—controlling erosion pays immediate benefits to the farmer. Data from Bethany and McCredie over a period of years show one inch of soil loss equivalent to a reduction in yield of 4 bushels of corn and 1.6 bushels of soybeans. Even with high soil treatments on Putnam silt loam, 1000 pounds per acre of 8-12-8 with corn in 1948, the difference of one inch in soil depth was responsible for a decrease of 3.15 bushels of corn. To prevent decreased yields as a result of erosion, soil loss on the glacial and windblown soils of Missouri should be 4 tons per acre or less annually. On the Northeast and Southwest Prairie claypan soils losses should not exceed 3 tons, while in the Ozark Region the loss should be 2 tons or less.

Effect of Soil Type on Erosion.

Data from the Soil Conservation Research stations indicate that various soils do not erode at the same rate even when under comparable conditions of slope and cropping. An evaluation of the different rates, referred to as soil factors, permits more widespread use of erosion data. The relative soil losses (soil factors) for the soils of Missouri were determined as follows:

| <u>Soil Area</u> | <u>Soil Factor</u> |
|-----------------------------------------------------------------------------|--------------------|
| Lighter colored loessial soils bordering the Missouri and Mississippi River | 1.2 |

| <u>Cont'd-Soil Area</u> | <u>Soil Factor</u> |
|------------------------------------------------------|--------------------|
| Shelby and associated glacial soils | 1.1 |
| Claypans, Northeast and Southwest Prairies of Mo. | 1.0 |
| Marshall and similar dark colored loessial soils | .9 |
| Sloping soils of the Ozark Region | .9 |

Nutrient Loss by Runoff and Erosion.

Valuable plant nutrients are lost from the farm by erosion. Conservative estimates for Missouri upland soils indicate \$1.20 worth of potential plant food is removed with each ton of soil lost. The value of the annual loss in potential fertility for the state is estimated at \$192,624,000 at current prices.

The emphasis on soil testing and higher rates of fertilizing to produce high yields gives reason for additional attention to holding soil losses to a minimum. Soil made "richer" by the addition of plant food becomes a more valuable asset and as such merits superior protection against its loss.

Reclamation of Severely Eroded Land.

Many severely eroded areas of the state can be reclaimed and made to contribute to the farm income. It requires the expenditure of funds for erosion control and fertility improvement in addition to judicious management. One such area on the experiment farm at McCredie has paid the total cost of reclamation and returned \$33.89 per acre annually in the last three years. Current local prices were used in the computations.

Supplemental Irrigation.

The recurrence of midsummer droughts in the past has focused attention on the possibilities of supplemental irrigation in Missouri. A preliminary study on this subject was started at the farm in 1948. The general objectives are: (1) to determine when, how, and how much to irrigate; (2) to determine the effect of irrigation on crop yields; and (3) to survey the potential erosion problems created by irrigating upland. No data of significance were secured during the year, it being almost an ideal year in precipitation amount and distribution.

Grazing Study.

Grassland farming continues to be excellent land use of claypan soil in this area. Soil and water losses were below average in 1948 despite

almost normal rainfall. Production varied from 111 (2 months grazing of Korean lespedeza following an oat hay crop) to 408 pounds (6 months grazing of wheat and Korean lespedeza) per acre for the year. One system, rye pasture-soybeans for grain, produced 99 bushels of corn equivalent. Each of the 4 pastures which cover all years of experimentation at McCredie has averaged above 38 bushels of corn equivalent annually. Three promising new pasture mixtures under study are bromegrass with sweet clover, alta fescue with birdsfoot trefoil, and Ladino clover with a grass.

Crop Sequence.

Results during 1948 emphasize that corn and soybeans can be produced without serious erosion if grown in the proper sequence with cover and soil conditioning crops. As an eight-year average, corn following a 2-year grass and legume meadow allowed only 23% as much erosion as corn following oats without a soil conditioning crop. When the soil conditioning crop was one year meadow instead of two, the erosion was 32%, and with sweet clover plowed under as green manure it was 43%. With soybeans following a one-year grass and legume meadow crop the erosion was also 23% of that for the corn not preceded by soil conditioning crops.

Lespedeza with the full growth of the previous year plowed under before corn has been nearly as effective as sweet clover in soil conditioning. When it was removed for hay, the effect was not significant.

Erosion between corn and soybean crops during the 6-month period from late fall to early spring was materially reduced by a cover crop of rye. However, erosion during this period averaged less than 9% of that from the complete rotation cycle. The important effect of the rye was in reducing both runoff and erosion under the beans that followed plowing under of the rye. That rye starts spring growth before other small grain, the grasses, and the clovers, has been shown by the March and April runoff records. This is of significance in farming these claypan soils that are usually wet and slow to warm up in the spring.

Corn yields were exceptionally high in 1948 when there was high fertility and a favorable soil physical condition in addition to the favorable weather. Without fertilizer and the favorable soil physical condition the yield of corn was only 28 bushels. With relatively high rates of fertilizer and either grass-legume meadow or sweet clover as green manure, the yields were over 100 bushels per acre. Second-year corn with equal fertilizer yielded less than half that of first-year corn. Small grain, following soybeans (grain beans with straw returned) yielded as an average 70% more than small grain following corn, both with the same amount of fertilizer (200#/acre of 10-20-20).

Stand was an important feature of high yield. Corn with 12 to 13 thousand stalks per acre, while yielding from 103 to 128 bushels per acre, was outyielded by corn with 14 to 15 thousand stalks per acre. Soybeans with a poor stand resulting from a surface crust formation yielded about half that of similarly treated beans where the stand was not reduced by a surface crust.

Fertilizer in Soil Conservation.

The value of adequate fertility becomes increasingly apparent with each year of study at McCredie. Soil treatment plays its greatest role in conservation through its stimulation of plant growth. Thick stands of vigorous plants provide better cover and better soil conditioning and hence, significantly reduce erosion. At the same time, higher yields are obtained, which reduces the acreage required for equal total yields. This value of fertilizer is of major importance in soil conservation when it encourages a reduction in farm acreage planted to the most erosive crops - row crops and small grain.

Building a Deeper Soil.

The advantage of a deeper soil; that is, 16 to 18 inches instead of 7 to 9 inches of soil well supplied with plant nutrients was minimized this last year as a result of the favorable rainfall and temperatures during the summer growing season. Thus, the plant roots were not forced to feed in the lower horizons for moisture and nutrients. Crop yields from plots with the subsoil shattered, limed, and rock phosphated were greater than from the undisturbed subsoil, but not a significant amount. They were high for the check as well as for the deep-treated plots. Alfalfa and bromegrass yields (first crop year) were increased by 3/4 ton per acre by the deep treatment which included one ton of lime. Without the lime the increase was only 1/4 ton.

Terracing - Terrace Outlets.

A preliminary survey of terrace outlets indicated that failures were the result of numerous factors or combinations of factors, including (a) low level of phosphate, (b) low organic matter and nitrogen, (c) concentration of nutrients in the surface few inches, (d) neutralization of soil acid by excessive liming, and (e) improper management of the grass for hay; that is, mowing with a very short stubble when the grass was maturing and producing seed.

Work at McCredie and Columbia indicates the necessity of raising to a desirable level the nutrients in the surface 14-inch layer of soil instead of concentrating them in the surface few inches. This may be done by using (a) rock phosphate, (b) manure, or composting in the soil hay or straw with a nitrogen fertilizer, (c) potash fertilizer and (d) lime to a pH between 5 and 6, all as determined by soil tests.

Maintenance of fertilization will nearly always require annual application of nitrogen, and in addition on hay producing outlets, potash or even some readily available phosphate.

Definite recommendations of fertilizer kinds and rates and practical methods of application in establishment and maintenance, and also the handling of the hay or seed crop from the outlets, can be made with assurance only after further research and field testing.

Rate of Runoff from Terraced Areas.

Terracing reduced the 10-year recurrence rate of runoff on Shelby soil by 41% on an 8-acre area. The reduction was greater for recurrence intervals more frequent than once in 10 years. For areas greater than 8 acres in size the percentage reduction is not known for experimental data, although it has been assumed to decrease with increased size of drainage area. Ninety-four percent of the total runoff during a 10-year period from cultivated Shelby soil that was terraced occurred at a rate of 0.1 inch per hour or less.

Terrace Grade and Spacing.

Grades of 4 and 6 inches per 100 feet have not caused outlet silting on claypan soil when proper attention had been given to the soil-crop phase of conservation. Two-inch grades resulted in crop damage and delayed farming operation on these soils the same as on the moderately eroded Shelby soils. Soil areas that have a high potential infiltration capacity, uniform land slopes, and are well managed from a soil fertility and organic matter standpoint, have possibilities for double the present spacing recommendation.

Depreciation Rate.

Well managed terrace systems that are not plowed up-slope in the regular farming operations have a theoretical depreciation rate of around 7 percent. Under actual farm conditions it is probably about 50% higher than this figure.

Havre, Montana. T. S. Aasheim, Project Supervisor.

The Effect of Crop Residues and Tillage Method on Soil and Moisture Conservation and Crop Production.

In 1941 a study was started at the North Montana Branch Station near Havre, Montana, for the purpose of determining how crop residues and tillage method affect soil and moisture conservation and crop production.

This project was revised in 1947 so as to get information each year on crop yields from plots on which tillage method is rotated along with plots on which the same tillage method is used year after year.

The sub-surface tiller, oneway and moldboard plow are the three implements being used and they are being used in that sequence on the rotation plots. Yields are available for seven years from plots which have been cultivated continuously with the same implement. This is the first year that yields have been obtained from fallow on which tillage is rotated. The table below summarized yields obtained on this project this year.

| Tillage method | | Bushels wheat per acre 1948 | |
|----------------|---------|-----------------------------|------------------------|
| | | Same tillage continuously | Tillage method rotated |
| M.B. Flow | T | 8.8 | 8.2 |
| M.B. Flow | B | 9.6 | 8.9 |
| Sub-Surface | T | 8.9 | 9.8 |
| Sub-Surface | B | 9.2 | 9.9 |
| Oneway | T | 9.2 | 7.6 |
| Oneway | B | <u>10.7</u> | <u>9.7</u> |
| | Average | 9.4 | 9.0 |

T - Stubble not burned
 B - Stubble burned

This table indicates there was very little difference this year between plots where tillage implements were rotated as compared with plots on which the same implement was used continuously. The sub-surface tilled treatments consistently averaged higher yields in the rotation system while the fallow which was oneway and moldboard plowed had a higher average yield on plots not in the rotation system.

For the past three years yields have been determined from total plot yields as well as by the quadrat method in this project. Twelve-meter square quadrats are harvested from each plot, plots are slightly less than one half acre in size. The average yield for the three-year period as determined by the total plot method is 13.3 bushels and by the quadrat method the average yield is 12.3 bushels.

The Effect of Contour Tillage on Soil and Water Conservation and Crop Production.

This project has been in operation since 1942. Plots cultivated on the contour have contained an average of 10.8 percent of moisture per foot of soil for the six-year period and plots cultivated up-and-down hill have averaged 10.0 percent. Plots cultivated on the contour have had a little more moisture every year than plots cultivated up-and-down hill. Grain yields have not followed this same pattern, the average yield per acre for the six year period is 18.6 bushels per acre on

the contoured plots and 18.8 bu. on plots cultivated up-and-down hill.

Control of Weeds on Summer Fallow by Use of 2,4-D and Other Chemicals.

This project was initiated in the spring of 1948 at the North Montana Branch Station. The purpose of the project is to determine if it is practicable to use chemicals exclusively or in part for the control of weeds on fallow land. Ten treatments are included in the study. These treatments range from ordinary cultivated fallow to fallow on which only chemicals are used for weed control during the fallow period. Several combinations of tillage and chemicals are included.

The use of chemicals on fallow for weed control has many advantages over tillage if it can be used as cheaply and if yields can be maintained. It is faster and therefore may result in more timely killing of weeds. Extremely wet or dry conditions would be more apt to stop tillage operations than spraying. Chemical spraying might be used to hold weeds in check so that the operator can get over his land before weeds get too far along. If chemicals can be used to substitute for one or two tillage operations it will result in less pulverization and more residues on the surface. If stubble can be left standing for two winters instead of one by using chemical sprays then summer fallowed land will benefit from two years' snow accumulation instead of one. Snow accumulations in stubble have been found to add a considerable amount of moisture to the soil in some parts of Montana.

During the 1948 fallow season Russian thistles were found difficult to control. The sprayed thistles did not get very large but there was still a pretty fair thistle cover on the ground. Soil moisture samples taken this fall to a depth of four feet averaged 9.2% moisture per foot on cultivated fallow, 4.6% on fallow sprayed with 2,4-D, and idle land averaged 3.7%. The gravelly soil accounts for the low moisture percentages. From this year's observation at this location, the use of 2,4-D for the first operation followed by tillage for the balance of the fallow period seemed to be the most promising method of incorporating the use of chemicals into the fallow system.

Effect of Time of Tillage and Tillage Method on Soil and Moisture Conservation and Crop Production.

This project was started in 1947 at the Central Montana Branch Station near Moccasin. It was set up to help answer some of the questions in connection with fall tillage, chiseling and stubble mulch tillage in the winter wheat area of Montana. Stubble mulch tillage meets with more opposition in the winter wheat areas due to the shorter time between harvest and seeding. The shorter interval results in less brittle and longer straw which is more difficult to seed through.

Froid Field Trial.

Four Soil Conservation Districts in North Eastern Montana are now cooperating in this field trial along with the Extension Service, Agricultural Experiment Station, Soil Conservation Service and the Moen brothers of Culbertson, Montana. The Soil Conservation Districts are paying for all labor used in connection with the work and the Moen brothers are furnishing the land, seed and fuel. The Soil Conservation Service is furnishing some equipment and the work is under supervision of the Project Supervisor. The Extension Service assists with field days and other educational activities. The Montana Agricultural Experiment Station assists in threshing grain samples and offers technical assistance.

This field trial now consists of eight fallow methods which were suggested by the Supervisors of the sponsoring Soil Conservation Districts. The treatments include fallow which is sprayed with 2,4-D, sub-surface tilled, moldboard plowed and onewayed. In addition to these basically different fallow methods treatments are included to evaluate the practices of fall blading of stubble land and chiseling.

Fallow sprayed with 2,4-D at this location looked very good this year. Spraying was done at the rate of .4 lb. 2,4-D, in the ester formulation, on May 24 and June 25. It was necessary to sub-surface till all sprayed plots on July 27 in order to control volunteer wheat, wild oats, pigeon grass and wild buckwheat. Control of grasses, of course, was not expected with 2,4-D. Soil moisture samples taken this fall on sprayed and cultivated fallow showed very little difference in the amount of moisture present in the two types of fallow. The fallow which was sprayed twice and cultivated once averaged 13.6% moisture per foot to a depth of five feet and the ordinary sub-surface tilled fallow averaged 15.0 percent per foot. Stubble is still quite upright on the sprayed plots and a lot of snow is being held on them this winter. Cultivated fallow is almost entirely bare.

Other Field Trials.

Several field trials and demonstrations of stubble mulch tillage are located around the State. These are being conducted in cooperation with the Extension Service, Montana Agricultural Experiment Station and the Operations Division of the Soil Conservation Service. The purpose of these trials and demonstrations is to better acquaint farmers in different areas on how to carry on a system of stubble mulch tillage on their fallow land and also to get additional information on the adaptability of the practice in these areas.

Results which have been obtained to date indicate that as long as operations are timely and erosion is kept under control there is very little difference in the productivity of summer fallow for producing spring wheat regardless of tillage method used. Stubble mulch has proven to be very effective in controlling soil drifting and also reduces water erosion.

Lincoln, Nebraska, Dr. F. L. Duley, Project Supervisor.

1. The cooperative soil and moisture conservation work conducted cooperatively by the Soil Conservation Service--Research, and the Nebraska Agricultural Experiment Station has been in progress for eleven seasons or since 1938. The work during 1948 was largely a continuation of progress made on a number of projects throughout the period.
2. The results to date have emphasized the value of some protective covering on the soil to reduce runoff and erosion. The measurements as well as the continued experience in growing crops on land protected with crop residue continue to show that both runoff and water erosion can be greatly reduced by proper use of this method.
3. During 1948 weather conditions were generally favorable and good yields of all crops were produced.
4. Although the rainfall was somewhat above normal in 1948, there were only a few rains that gave runoff. This was a good year to illustrate the effect of cover at time of rain on erosion. No erosive rains fell in spring when there is usually most bare soil exposed.

Special attention should be given to make sure of protecting soils at times when erosion is likely to be most serious.

5. At Lincoln there are periods when erosion is likely to be most serious. One is at time snow goes off in early spring, a second is during May and June when row-crop land is exposed, and a third is in August and September when wheat and fall seeded meadow crops may mean bare soil. In our work special attention has been given to protecting the soil with residue at these particular times.
6. From determinations made on small cylinders, it appears that the effect of mulch in evaporation control is greater during spring and fall. If this is true, it probably is during these periods of low evaporation that we have the best opportunity to replenish soil moisture in Nebraska soils.
7. Results to date indicate that stubble-mulch farming is a more satisfactory practice when used with a good system of farming which includes the use of legumes to maintain an ample supply of available nitrogen.

8. Biennial sweetclover has been found to be a very satisfactory legume for soil conservation in eastern and central Nebraska. It can be used as residue by being subtilled at the beginning of the second year when it is about 8 to 12 inches high.
9. Sweetclover may also be harvested for seed or clipped about blossom stage and the residue left on top of the soil. The land can then be prepared for seeding grass or fall wheat or it may be allowed to lie on the surface until the following spring. The land may then be seeded to a spring small grain like oats or it may be subtilled and put to a row crop like corn.
10. In cooperation with the Nebraska Station, various annual legumes are being tested for their adaptability for use in a stubble mulch system. Partridge peas, vetch, trailing beans, annual sweetclover (Hubam, and lespedeza (19604) have been grown since 1945. It is hoped that with the stubble-mulch system some of these annual legumes may come in as volunteer whenever conditions permit. They therefore act as legume weeds. Thus they might do much toward maintenance of the nitrogen supply. Birdsfoot treefoil (a perennial) is also being grown for one phase of the work.
11. Partridge peas (Chamaecrista fasciculata, Michx.) has been found to be one of the most promising so far as volunteering in small grain is concerned. Some fields seeded to this legume in oats in the spring of 1945 have continued to produce good stands in small grain where it has been alternated with corn.
12. Lespedeza (19604) has also given good volunteer stands, but they are not always as good as the partridge peas. The lespedeza does have the advantage of making a good pasture crop after the small grain is removed.
13. Vetch has been fairly satisfactory on sandy soil where good stands have been obtained. It seems to require more careful methods of seeding. Annual sweetclover is soon killed out by early subtilling and does not remain in fields as a regular volunteer crop. It must be reseeded.
14. Sweetclover used as a green maure crop or left on the surface by subtilling has served the double purpose of greatly reducing runoff and erosion and supply available nitrogen to the following crop. Corn yields at Lincoln have been increased 37.6 bushels per acre, wheat 13.6 bushels, and oats 37.5 bushels by using sweetclover in the rotation as residue, over land where no sweetclover was grown.
15. Second-year sweetclover should be subtilled when the plants are about 8 to 12 inches high. If allowed to stand too long the large sweetclover plants deplete the subsoil of moisture very rapidly. This is one of the chief reasons why farmers have trouble with corn after sweetclover.

16. Second-year sweetclover mowed when in early bloom stage and allowed to lie on the ground made excellent residue to protect fall grass or wheat seedings. Furthermore, it supplies nitrogen to give young grass or wheat a quick start. Used in this way, sweetclover is an excellent crop for rejuvenating badly eroded land.

17. In planting sweetclover, care should be taken to protect the land against erosion while the crop is getting started. If there are corn-stalks on the land, they should be cut and the land subtilled so that this protection can be left on the surface. The planting can be done very satisfactorily with a drill or with a treader having grass seeder attached.

18. A new type of skew treader built at our suggestion has been developed by one machinery company. This has two single lines of fingered wheels. These are hitched together with a short adjustable tongue. The two lines of wheels can be brought close together at one end and tied with a chain. In this position they pull on the skew. This gives them a sidewise action which aids greatly in weed eradication.

These skew treaders are of great value in weed eradication following subtillers. They may also be used in cultivating young row crops when planted in furrows.

19. Chisel-type tillers have been tested and found of value as a preliminary treatment in breaking hard ground. The regular sweep-type subtiller penetrates more readily and leaves the ground in more pulverized condition where the chisel has been used for the first operation. The chisel is particularly valuable in hard dry ground after harvest, but may also aid in preparation of seedbed for row crops in the spring.

20. Different types of straw cutters have been built by machinery companies. The idea is to reduce heavy straw to short lengths so that tillers will pass through with less trouble from clogging. The value of this practice in a stubble-mulch system has not yet been definitely determined. Other methods now in use may work just as satisfactorily.

21. At the Hastings Project oats following corn after one-year sweet-clover gave 45.3 bushels per acre, while oats following corn where no sweetclover had been grown yielded only 20.8 bushels per acre.

22. Corn after sweetclover gave a yield of 19.6 bushels on subtilled land, but on account of drought gave only 6.1 bushels on plowed land.

23. Wind erosion was less severe in 1948 than 1947. Farmers are making serious effort to protect their land from blowing by the use of residue. The chief difficulty is to retain enough residue through the season of fallowing to protect the land after the wheat is seeded. Some men are inclined to overwork their fallow land. This tends to dissipate the residue.

24. Microbiological studies indicate that Azotobacter are not present in most soils of eastern Nebraska. Some were found at the Hastings Project, but there is no evidence so far to indicate that they compare at all with legumes in improving poor soils.

25. Laboratory studies are being made on the effect of crop residue on germination of corn. This is an attempt to explain field observations of repression of growth on mulched land. This is most noticeable in periods of wet weather and during the early part of the growth period.

26. Studies on earthworm population in stubble mulched land indicate that it may be increased, but there appears to be a change of species. Further work on this problem will be done in 1949 by one of our graduate students.

27. The project needs considerable expansion due to the activity in the Missouri Basin at this time. Plans for additional work are being considered in connection with an expanded program for various State and Federal agencies.

New Brunswick, New Jersey, O. R. Neal, Project Supervisor.

Crop Rotation for Runoff and Erosion Control.

The rotation of cultivated crops with grass-legume mixtures at regular intervals is an effective conservation practice. During the 1948 growing season areas in tomatoes on continuously cultivated land lost 9090 pounds of soil per acre and 2.96 inches of runoff. In the same period areas in tomatoes in a rotation which included a sod crop, winter cover crop and compost, lost 4320 pounds of soil and 1.53 inches of water. Under identical fertilizer treatment, tomatoes in the former case yielded 11.9 tons of fruit per acre while the yield in the latter case was 18.0 tons per acre. Similar conservation and yield effects were obtained with a sweet corn crop.

Seasonal Nature of Erosion Losses.

Essentially all of the soil loss for the calendar year occurred during the growing season. This was true even on treatments which have no winter cover crop. This substantiates the observation that, within reasonable limits, runoff and erosion are more dependent on intensity of rainfall than on amount. Ninety-nine percent of the rain falling at an intensity above 1.00 inch per hour came during the growing season.

The Influence of Crop Rotations and Organic Matter Treatment on Rate of Runoff.

The soil treatments which are most effective in reducing total amount of runoff are also effective in reducing maximum rates of runoff. In general, however, the reductions in rate are relatively smaller than are the reductions in amount.

Cover Crop Comparisons.

The value of winter cover crops for reducing soil and water losses during subsequent periods of cultivation has been shown repeatedly. Such crops also influence yields of cultivated crops. Sweet corn yields following rye cover have shown a 4-year average of 7370 ears per acre. The average following ryegrass has been 6210, while after a ryegrass-vetch mixture the yields have averaged 10,000 ears per acre.

Effects of Land-Resting on Conservation and Crop Yields.

Periodic resting of cultivated land in sod or other non-cultivated crops has brought about large reductions in runoff and erosion. Average growing season losses from continuously cultivated areas in sweet corn over a 5-year period are 3990 pounds of soil and 3.70 inches of water. During the same period sweet corn areas which are rotated with clover sod lost 1620 pounds of soil and 1.36 inches of water.

Areas rested in various organic matter producing mixtures in 1946 have shown marked increases in sweet corn yield during 1947 and 1948. The total production of corn in two crops following the resting period has been greater than was obtained from three crops under continuous cultivation.

Influence of Depth of Topsoil on Crop Yields.

Crop yields are lowered as erosion continues. Field measurements have shown consistently higher yields of potatoes, corn, wheat, rye, barley, oats, soybeans, and alfalfa on less eroded areas.

Cultivation versus Chemical Weed Control.

A preliminary comparison of cultivated areas with uncultivated areas where weeds were controlled with chemicals was carried out. Soil and water losses during the cultivation period were higher from the chemically treated area. There was tendency, however, for a reversal of this trend after cultivation ceased. Physical conditions of the soil after cessation of cultivation appeared to be poorer as a result of the several cultivations. Additional work is needed on this problem.

Conservation Practices in Sweet Potato Production.

Cover crop and land resting treatments which are known to be effective in conserving soil and water have also increased yields of sweet potatoes. Areas cultivated each year without winter cover averaged 161 bushels of No. 1 potatoes in 1948. Similar areas which have had rye cover each winter produced 239 bushels. Areas rested during 1947 in winter cover followed by broadcast corn followed by winter cover produced 275 bushels per acre.

Physical Properties of the Soil in Relation to Conservation.

A variety of crop rotation, land-resting, and organic matter treatments known to influence physical properties of the soil were in operation during the year. Indirect evidence of differences in physical soil conditions was obtained through numerous measurements of runoff, soil loss, and crop yields. Direct measurement of physical properties in the laboratory was at a standstill during the year due to personnel shortage.

State College, New Mexico, D. S. Hubbell, Project Supervisor.

Summary on Soil Structure Studies and Statement of Practical Applications.

Studies have been conducted on the properties of calcareous soils that influence the formation of water-stable aggregates, soil friability, and cotton yield. This investigation has been carried out in the

laboratory as well as in the field and has been confined to a Gila clay soil.

In the laboratory it has been determined that sand, silt and 5 micron clay do not aggregate whereas 2 micron clay will aggregate almost 100% after 120 days of incubation. It was further determined that the presence of sand and silt in a soil always reduced the percentage of the soil aggregated, with the silt fraction reducing the aggregation to a smaller extent than the sand fraction. The fineness to which soil particles are reduced definitely affects the rate of water-stable aggregation as well as the size of the aggregates. Soils ground to a diameter of .12 mm. may not assume a normal rate of aggregation before 12 months of incubation and the type of aggregates are invariably fungal, which means that the soil is in a puddled condition. Coarse-ground soils with a diameter of 2.00 mm. maintained larger water-stable aggregates than did soils ground to 1.19 mm. No difference in total aggregation could be noted. Under ideal conditions, water-stable aggregates in the larger particle sizes fluctuated but slightly in total aggregation; there was, however, wide fluctuation among the sizes.

These laboratory studies indicate that under field conditions soils should not be pulverized. They further indicate that estimations of the potential aggregating power of a soil can be made after percentages of sand, silt, and 2 micron clay have been determined.

Field studies have shown that tillage (cultivation) has no significant effect on the formation of water-stable aggregates, on the soil friability, or upon cotton yield. Compaction, on the other hand, while not affecting water-stable aggregation did decrease the friability of the soil. Compaction had little or no effect on cotton yields. Soil mulches were ineffective as improvers of soil structure or cotton production, but tar paper mulch increased cotton yield without changing the structure of the soil. Sub-irrigation in raised seedbeds proved to be a superior method of maintaining soil friability and increasing cotton yield, but had no effect on water-stable aggregation. The data from these field experiments indicate that many farm operations are costing the farmers time and money and are contributing to soil deterioration without increasing crop yields.

Summary.

In the study of the possibilities of controlling arroyos by means of vegetation, an attempt was made to discover some of the early steps in vegetational recovery that seem to be influencing arroyo activity in southern New Mexico. It seems probable that invasion of small gullies and runlets on the drainage area by undershrubs or grass is a contributing factor, and that the invasion of the arroyo channels by shrubs (desert willow, apache plume, etc.) that break up and deflect the flow and tend to stabilize the bottom greatly reduce the amount of water reaching the mouth of the wash. Planting blocks of such shrubs across the wash seems to offer a possible method of speeding up this process. Natural recovery under protection from grazing

appears to be very slow in the Desert Grassland, even under favorable climatic conditions. On one such area, plowed from 1914 to 1918 and protected from livestock for the past 30 years, the original tobosa grass has not reclaimed the area, and the present density of perennial vegetation is only about half that of the contiguous undisturbed tobosa grass.

Ithaca, New York, John Lamb, Jr., Project Supervisor.

Outstanding Developments of 1948.

In the balance of water and air in the soil under the climatic conditions of the Northeast, there is frequently too much of the former and not enough of the latter in the spring. In the summer, there is just as frequently a shortage of water. Drainage is especially essential in the early part of the season, in order to get the root system established in a large volume of soil and reservoir of water before the dry periods. Drainage depends as much on a favorable soil structure as on adequate, large, man-made waterways.

The first and practical way to make up for water shortage is to stop the obvious leaks. The second is to introduce water by irrigation. Contour tillage stops one important leak, and usually gives an immediate increase in crop yield, as so often demonstrated on all the soils thus far worked with in New York. Then, there is the long-time effect; by reducing runoff, we reduce erosion and maintain a more favorable soil structure. A protective litter on the surface stops part of the same leak; it also breaks the fall of the raindrop, and insulates the soil, reducing evaporation. Thus, it keeps the soil in a structural condition to take in water faster, and to move through the soil faster. However, at Marcellus, disking and subsurface plowing which keep crop residues on the surface have not been as satisfactory as conventional plowing from the standpoint of yields of corn and small grain. Protective litter has improved alfalfa stands. In another experiment, manure applied to corn after plowing and planting has maintained yields and reduced erosion.

The loss of soil by the selective process of sheet erosion has proved very detrimental on all four soils studied. The loss of fine material high in organic matter causes a rapid deterioration in soil tilth. The soil compacts readily. Movement of water and air into and through the soil is restricted. There is more runoff and not enough fresh air for good root development. If a plow sole is developed, this may increase the water held close to the surface, and increase the loss by surface evaporation. At Geneva, after 1,000 pounds of 10-10-10 was applied to corn in 1947, and again to corn in 1948, the yield varied with past erosion from 40 to 106 bushels to the acre. At Marcellus, after a year of oats, two years of alfalfa, and one year of corn in 1947, eroded land was only 85 percent as efficient as the uneroded land in producing corn in 1948, even though 1,000 pounds per acre of 10-10-10 was used there also last year.

Even a few years of relatively mild erosion may show serious effects for many years. This was demonstrated both at Marcellus and the Arnot. More soil has been lost from plots with rows up and down the hill than from plots with rows on the contour. At Marcellus in 1948, one such series of plots was in oats, the other wheat. With low-intensity rains and little runoff, any current differences in yield associated with direction of row were due to recent erosion. With crops on all paired plots the same throughout the experiment, erosion was the only variable. Oat yields on the contoured plots were 49.1 bushels per acre, and 44.8 on the up-and-down-hill plots. The corresponding yields for wheat were 39.9 and 33.6. The soil and nutrients lost from the up-and-down-hill plots are trapped by the undisturbed grass below, where there are well-defined deposits of topsoil and a superior growth of grass. At the Arnot, even after two and three years of clover and grass, corn planted on the contour on all plots in 1948 made 53.9 bushels per acre on the old contour plots, 4.1 bushels more than on the old up-and-down-hill plots.

After we have done the best job possible of stopping water leaks, and water is still short, irrigation is the next step. It may be used to assist the plant over a critical period when the total rainfall for the season may be ample but the distribution poor. It may be used to produce high yields and quality of high value crops almost any season; or with low rainfall, it may be a must for satisfactory yields. There is seldom a year when one, or even all three conditions, exist some place in the State. This year in Niagara County, the total rainfall for June, July, and August was reported to have been approximately 3 inches. The Weather Bureau data for Buffalo and Rochester show totals of slightly less than 7 inches for the period. Many crops were a failure. At Sodus, New York, irrigation increased the yield of tomatoes from a high yield of 14 tons per acre to a very high yield of 19.5 tons. The same result was secured with snap beans. At the Arnot with good total rainfall, irrigation helped pasture grass through a short, dry period.

Raleigh, North Carolina, T. L. Copley, Project Supervisor.

Summary of Research Results.

Studies on the Raleigh Station have consisted mainly of the following:

1. A study of the effect of cover crops and crop residues on the growth of tobacco and on runoff and soil loss.
2. A study of the effect of row grade and length on the growth of tobacco and on runoff and soil loss.
3. A management and yield study on the use of surface mulch in some of the local cropping systems.
4. A management and yield study of the use of kudzu in corn-grain rotations.

Cover Crop Studies.

Cover crops and residues tend to increase yields of tobacco where a sufficient growth is produced and when the green manure decomposes early and becomes available to the plant. Where a more resistant residue is produced, as in the case of rye grass, no increase in yield has been noticed. Most of our soil loss occurs during the period from May through August. Thus, the conservation value of cover crops and residues depend on their protection to the soil in that period. To be effective such residues must last into this summer erosion season and, if possible, be retained on or near the surface. The protection provided by such residues during this summer period is not sufficient to be considered good erosion control unless the material is retained on the surface. This being so, we must depend on other practices during this time of acute erosion risk.

Row Grade and Length Studies.

The grade on the crop row is highly important and may determine the amount of soil lost during the row-crop year. If a moderate, controlled row grade is provided so that each row can carry its own water, as in tobacco culture, the row pattern will reduce the effect of field slope. The String Method of row layout, perfected at this Station, tends to provide an effective row pattern, which reduces the results mentioned above.

Row lengths, such as were used in this experiment, had no affect on the amount of erosion. Soil losses were practically the same on the two lengths employed.

No differences in growth of tobacco have resulted from the different grades used in this experiment. Field results, however, have shown that with the proper row layout, where each row tends to drain properly, runoff water is distributed uniformly over the field and this in turn results in a more uniform growth of tobacco. This is highly desirable in tobacco production and tends to result in an increase in both yield and quality.

Surface Mulch.

The Surface Mulch study includes (1) the use of a lespedeza mulch on corn in a 3-year rotation of corn, wheat and lespedeza hay, (2) the use of a rye-vetch winter cover residue as a mulch with continuous corn, and (3) three methods of preparation of lespedeza land for wheat in a continuous lespedeza-wheat rotation.

Results show a marked decrease in yield of corn under the lespedeza mulch as compared with the turned and clean tillage. This is, apparently, due to a deficiency of nitrogen or some other element. Different methods of preparation of land for wheat, following corn, have shown no difference in yield.

Corn, following the rye-vetch winter cover, has yielded as well under mulch as with conventional tillage. Insect damage, particularly wire worm infestation, has consistently decreased stands following this rye-vetch winter cover. In the continuous wheat-lespedeza system wheat yields have been approximately the same after turning, disking and subsurface breaking. After this system had continued for several years rye grass began to volunteer and soon became thick enough to seriously interfere with wheat. The plots then had to be turned to kill the rye grass.

Corn-Kudzu Rotation.

This experiment has not been going long enough to draw definite conclusions. However, preliminary results indicate that kudzu may, under certain conditions, be a useful legume for corn-grain rotation. The kudzu is being plowed up and a normal crop of corn grown. The kudzu quickly covers the ground after the last cultivation of corn. The corn may be harvested for silage, it may be harvested for livestock, or it may be harvested as mature corn. The latter method may be somewhat more difficult than usual because of the kudzu runners. Oats are following corn and making normal growth. This crop, however, has to be mowed for hay or grazed off, since kudzu will start growing and be in the way of combining the grain. Kudzu is volunteering and re-establishing itself after oats are harvested.

Demonstration Practices on Non-experimental Areas.

Non-experimental areas on the Station farm are utilized to demonstrate recommended erosion control practices which go to make up a balanced plan for a tobacco farm. These include, (1) a terraced tobacco field, with rows laid out by the string method, (2) rotated strip cropping with corn, wheat and lespedeza, (3) a 5-acre alfalfa field, and (4) pasture area, using kudzu and sericea in conjunction with permanent grass and legume mixture. A small herd of beef animals is kept to utilize the pasture and surplus hay.

These practices, along with the experimental plots, are proving to be of considerable interest to the many visitors to the Station.

Fargo, North Dakota, Carl L. Englehorn, Project Supervisor.

Summary of results.

1. From the standpoint of moisture conservation very little or no more moisture has been conserved by stubble mulch tillage than by plowing or other tillage practices. This is perhaps due to the fact that the field plots for these studies are located on relatively level land where though rate of absorption of water may vary, final total amount of absorption will be the same regardless of the type of tillage.

2. At Edgeley yields from stubble mulch fallow have equalled those from plowed fallow; at Langdon they have been only slightly less. Stubble mulch tillage for summer fallow should be preferred for the protection which it gives the soil during the long period of time at which otherwise soils remain unprotected against wind and water erosion. It especially should be used in the areas of light soils and low rainfall.
3. As a 9-year average, spring plowing for seedbed preparation, continuous wheat, has produced, at Edgeley, 19.0 bushels of wheat, while stubble mulch tillage has produced 16.1 bushels, disking 16.5 bushels and tillage with the field cultivator 16.5 bushels. However, since 1945 stubble mulch tillage after the addition of 2 tons of straw an acre has produced a yield practically as high as plowing. The 4-year average was 14.6 bushels for stubble mulch tillage and 15.0 for spring plowing. Under continuous cropping at Langdon, however, fall stubble mulch tillage has consistently produced less than fall plowing. Here the average yields in bushels an acre for the 8-year period ending with 1948 was for fall plowing, 27.1; spring plowing, 21.4; fall oneway disk, 17.9; fall field cultivator, 17.2; fall stubble mulch, 16.3. The yields have been inversely proportioned to the amount of residue cover.
4. The field trial conducted on relatively steep land of a northwest LaMoure County farm showed a production of 17.3 bushels for spring stubble mulch as compared to 14.8 bushels for spring plowing.
5. The reason for the depressive effect of stubble mulch tillage on yield especially as exhibited under continuous cropping at Langdon, needs solution in order that modifications may be developed which will allow use of the practice without hazarding a yield penalty. Weed counts show no different in weed growth between the tillage methods under consideration; hence weeds have not been a factor. Nitrate determination show a tendency toward less available nitrogen under stubble mulch tillage than under plowing.
6. The lower availability of nitrogen has resulted not only in a lesser yield but also in a lesser protein content of the wheat crop. Tillage has affected yield, apparently, through its affect on available nitrogen.
7. The application of nitrogen fertilizer may correct the deficiency condition occurring with stubble mulch tillage. However, preliminary trials conducted during 1948 gave no results. On summer fallow the application of ammonium sulfate fertilizer seemed to depress the yield. The use of fertilizer in this connection needs further trial.

8. Phosphorous determinations on the wheat crop showed a higher phosphorous content in wheat from stubble mulch tillage as compared with wheat from plowing. The order of phosphorous content was the reverse of the order in protein content.
9. The temperature of the surface soil, as determined during the seasons of 1947 and 1948, has been lower under stubble mulch tillage than under plowing. The temperature difference was greatest at the beginning of the season, at a time during which it was of most importance. Though the differences were not of great magnitude, they were important in view of the fact that during the early part of the season the temperature of the stubble mulch soil was little higher than that required for microbiological activity. Furthermore, according to calculations based on 1947 data, the temperature of the plowed soil on May 1 was attained by the stubble mulch soil on May 25. It is believed that largely through its effect on soil temperature has tillage affected the supply of available nitrogen and consequently yield.

Wooster, Ohio, H. L. Borst, Project Supervisor.

Field Trial No. 1, "Establishing Legume-grass Meadow-Pasture Without Plowing."

The past season was the fifth for this study which is about completed. The following is a 1948 report on this trial, prepared for distribution to the districts and cooperating agencies.

Three new trash mulch field trial seedings were made this year in Harrison County, a comparatively new district. Of the three, 2 were excellent this fall and one was good. All were established on previously idle (or nearly so) land. The areas were all prepared in the spring. (The advisability of starting the preparation in the fall needs more emphasis in the districts.)

This year's seedings brings the number of "official" trash mulch field trials to a total of 90. Of these 80 (approximately 90%) have been classified as successful at the end of the first year. As indicated in previous reports some of the seedings which appeared to be failures the first year proved to be fair or better in subsequent years. The first year ratings on the 90 trials were as follows: excellent 19, good 27, fair 22, poor 13, failure 9. This is not a bad record.

Reports were received on the 1946 trials in Adams County and some of the 1947 trials in Harrison and Greene counties were visited. Earl Merandas' 10 acres carried 26 head of cattle from April 29 to August 15 (109 days) and furnished occasional grazing until December 1. Dry weather reduced the growth during late summer. This area carried an average of 3 head per acre from late April till October 1 in 1947. The alfalfa (only 3#/A. seeded) is thin but the Ladino is still in good shape.

As in previous years several areas were overgrazed. It is apparently too easy to let the livestock increase faster than forage land is provided for them. The high price of milk is probably partly responsible for this. Although we have no definite figures it appears that a majority of the men who started with trial areas have increased their trash mulch acreage, several fold. Eventually they should have adequate forage for their stock.

The place of trash mulch seeding in farm planning.

The trials have pointed out among other things where the trash mulch method of seeding is particularly useful. The idea that the trash mulching is the best method of seeding for all conditions is sometimes encountered in my travels over the State. This is not true. The trash mulch method is particularly valuable (1) where conventional procedures (plowing, etc.) would cause serious erosion, (2) where the organic matter content of the soil is low so that it is advantageous to utilize plant residues in and on the surface for the benefit of the seedlings (better biological and water relations), (3) where the fertility level is so low that putting the land through a conventional rotation would be unprofitable.

This means that the method is most useful on sloping land and on "poor" land, i.e., the poverty grass hills of eastern, central and southern Ohio. There is not much point in disking or cultivating a piece of plowing on level land for a seeding unless the organic matter is needed in the surface for the good of the seedlings. This is rarely the case.

Poverty grass and broomsedge and needle grass (annuals often associated with these two) are all shallow rooted. The first two often make quite a top growth. Covering this top growth by plowing to the necessary depth leaves a surface low in organic and root material. Not only is such a seedbed ready for erosion but it also may lack organic material beneficial to the new seeding.

As has been previously pointed out, idle and unproductive land can be returned to production via legumes and grasses. Usually such land should remain in grassland. Some areas can be used for "crop land" after being built up by the grassland treatment.

Trash mulching has been used advantageously to establish meadow strips simultaneously with the cultivated strips where a strip cropping system was being started on hitherto idle land.

Problems in trash mulch seeding.

A difficulty in using the trash mulch method which still bobs up is that of preparation, especially where tractors are not available. It just happens that the counties where tractors are not available are just the ones (steep and poor soil) where trash mulching is the best practice. There is no one solution to the problem. A horsedrawn field cultivator would help. Hiring a tractor is another out. One cooperator this year used his corn cultivator (tractor type) after he had disked some and thus saved preparation work. Starting the job in the fall is the thing to do. Often vegetation will cut up better if the soil is solid as it is in the fall. Then too there is less chance that the operator will become discouraged if the job is divided. Although we had used a rototiller for trash mulch preparation at Zanesville with little success, I saw one in operation at Malabar Farm this fall which was doing a fine job. It was equipped with beaters curved at the ends. The curve is apparently important. Although this implement will probably never be common in the hill section of the State it is of interest to know that it will do in one trip over the land what several workings with other implements will do. It may be valuable in pasture renovation in western Ohio.

Field Trial No. 2, "Contour vs. Slope Culture for Row Crops in Ohio."

This was the second year for these trials. The following is a report prepared for distribution to the districts and cooperating agencies.

Cooperative field trials of contour vs. slope culture for corn were harvested, is not reported because of poor trial conditions. Trials in two other counties were not harvested because of poor stand or other deficiencies.

As in 1947 we are interested in comparing the effect of contouring on yields on poorly or medium drained soils and on well drained soils. Whether or not the trials are properly grouped as to soil profile may be open to question. The Roby trial area in Logan County is called a 4 profile, but St. Clair also may be a 3 profile. As was done last year this trial is put in the poorly drained soil group. Both of the trials in Logan County are puzzlers. They were both good trials as far as site and stand were concerned. Perhaps the plowed under nitrogen accounts for the Torrence results but why is not apparent.

Mulch Culture Studies with the Corn Crop.

Numerous experiments have shown that a mulch which protects the soil surface from the dispersive action of rainfall is one of the most efficacious means of controlling erosion.

Studies at Columbus and Wooster, Ohio, show that a straw mulch on corn plots is conducive to high yields. It would seem that some mulch

method of growing corn (and other intertilled crops) could be devised which would not only control erosion but which would be conducive to increased production.

Erosion starts when raindrops (of erosive size and velocity) strike the soil surface. It is at this point that erosion should be controlled insofar as possible. Practices which are designed to control erosion by controlling or influencing overland flow are somewhat akin to a practice of locking the door after the horse has been stolen.

Experiment 32 was started at this station in 1946 to investigate the possibilities of mulch culture for corn. In this work an effort is made to utilize the rotation meadow residue as a surface mulch. In order to do this a field cultivator has been used in comparison with the moldboard plow to prepare the soil for corn. During the first 2 years of this experiment yields were depressed from 13 to 40 bushels an acre by the mulch culture. In 1947 the planting was delayed on the mulch plots. These plots remained too wet to plant some 3 weeks after the plowed plots were ready. This delay in planting was a factor in reducing the production of the mulch plots that year.

During 1948 some exploratory investigations were undertaken by the writer to ascertain at least some of the causes for the reduced yields from mulch culture on the Wooster silt loam.

Weed control has been difficult and inadequate on the mulch culture plots. The effect of weeds was evaluated in a small way by spraying one plot of a pair in the same treatment, with 2,4-D. More than this was not attempted because of possible interference with the main objectives of the experiment. Since the difference in yields on the sprayed plot and its unsprayed pair was 17 bushels it appears for this year at least weed competition on the mulch plots is one factor making for lower yields from mulch culture.

Stand counts showed 15 percent fewer plants on the mulch culture plots. Evenly distributed, this difference would probably not influence yields materially. The stand on the mulch plots was spotty, however, and there were long gaps with no plants. It appears that poor stand on the mulch plots was another factor accounting for low production.

In addition to poor stand and weediness the mulch plots have shown coloration evidences of nutritional and ecological deficiencies.

Guthrie, Oklahoma, Harley A. Daniel, Project Supervisor.

Summary

Methods of controlling erosion and bringing eroded and unused land into production are being studied on both crop and pasture land at the Red Plains Conservation Experiment Station, Guthrie, and the Wheatland Conservation Experiment Station, Cherokee, Oklahoma.

Moisture Conservation - (Working Plan R-1-1-2, Cherokee). Experiments designed to compare the effectiveness of plowing, listing, basin listing and leaving a stubble mulch on terraced and unterraced land is being studied on the Wheatland Conservation Experiment Station, Cherokee, Oklahoma.

Contour Cultivation and Terraces.

Where all cultivation was conducted with the slope, the least amount of runoff was from the mulch plots and the greatest from the listed plots. But, both listing and basin listing greatly reduced runoff water losses when listing followed the contour. In fact, during the past six years the amount of runoff was reduced 24.4 percent when the tillage followed the contour. This is an average of the four types of tillage. On steeper slopes (over 1.5 percent), however, a combination of terraces and contour cultivation is needed. The combination conserved an average of 42.0 percent more water than unterraced land cultivated with the slope.

The first and second years after the terraces were built the yield of wheat on the terraced and contour cultivated plots was less than on those cultivated with the slope. But, beginning with the third year the yields have been higher on the terraced and contour cultivated plots. With the exception of the first year contour cultivation alone also increased crop yields.

Plowing Affects Soil Movement on Terraced Land.

Comparisons were made of the movement of soil by different methods of plowing on terraced land. The method of plowing on the Red Plains Station, Guthrie, was back furrowing to the terrace ridge with a conventional moldboard plow and leaving dead furrows in the intervals between terraces. Where this method was used, soil was moved away from the interval and onto the terrace ridge. Plowing terraced land on the Wheatland Station, Cherokee, was with a two-way plow. With it all furrow slices were thrown in the same direction. No dead furrows or back furrows were left in the intervals. Consequently, the terraces and channels were maintained and there was no apparent change or lowering of the surface soil in the interval areas.

Tillage Methods for Wheat.

The highest average yield of wheat to date from the continuous tillage tests on the Wheatland Station has been produced on the plowed land. Yields have been lowest on the stubble mulch plots. The average yields on the listed and basin listed land have been the same, and they are only slightly less than on the plowed land. The mulched plots have consistently contained a heavy growth of cheat and weeds and the wheat plants have been attacked by an infestation of foot rot. But, where the tillage methods were rotated, weeds, foot rot, etc., have not been a serious problem.

Spreading and Conserving Runoff Water - (Working Plan R-1-7-1, Cherokee). The conservation value of collecting runoff water from higher, sloping land and spreading it on lower, more level, deep, permeable soil is being studied on the Wheatland Station at Cherokee, Oklahoma. This experiment consists of a series of level terraces with intervals of one foot in a "syrup pan" type arrangement. This forces the water to completely cross the field in the intervals between each terrace. The terraced land was completely flooded six times during the growing season of 1948. As the water moved slowly back and forth over such a large surface, much of the surplus was absorbed by the soil. The water retained produced an average of 47.8 percent more alfalfa hay than on adjacent unterraced areas. The terraces also prevented water from collecting in a pond that formerly developed in the northwest corner of the station.

Cropping Systems and Cover Crops - (Working Plan R-1-1-2, Guthrie).

Crop Rotation.

A crop rotation of cotton, wheat, and sweet clover has reduced the average soil loss 77 percent and runoff water 35 percent annually as compared to continuous cotton during 19 years at the Guthrie Station. Both the wheat and sweet clover greatly reduced erosion during the critical soil loss periods. However, the amount of soil removed from the wheat plot was 6.4 times more than that from the sweet clover.

The yield of seed cotton in the rotation the first and second five-year periods was less than on the continuous area. But, during the third period it was 58.5 percent higher and in 1945-48 it increased an average of 205.2 percent.

Cover Crops and Fertilizers.

Small grain and other winter cover crops are most effective for erosion control at the time of year when most of the runoff occurs. The best results were obtained when these crops received an application of fertilizer. Not all crops respond equally to fertilization. It is, therefore, best to apply the fertilizer to the crops giving best response.

Gully Control - (Working Plan R-1-1-6, Guthrie). In regrassing exposed subsoil and unweathered parent material, the problems common to this type of land must be overcome. Low fertility, poor physical condition of the soil, and lack of moisture and organic matter or biological life are perhaps the most serious.

The runoff water from the original channels should be diverted by installing contour furrows or ridges between gullies and above the sources of the gullies. Satisfactory results have then been obtained

by installing vegetative barriers of brush and crop residue, plowing down the gully banks, applying fertilizer and lime when needed and introducing legumes. After the legumes are established, grasses may be introduced by the seed-hay method.

Where this procedure has been followed, the density of the vegetation in the treated gullies was three times more than that of the untreated gullies. During the last five years of summer grazing, yearling steers on regrassed, eroded land have produced an average of 41 pounds of beef per acre.

Establishing and Maintaining Plant Covers - (Working Plan R-1-1-4 (a), Guthrie).

Grasses and Legumes.

These investigations include testing grasses and legumes for erosion control. Other studies include effect of tillage and fertilizers on the production of these plants. Best results have been obtained from weeping lovegrass (*Eragrostis curvula*), yellow bluestem (*Andropogon Ischaemum*) and Caucasian bluestem (*Andropogon intermedius*). Weeping lovegrass is easy to establish even on eroded soil. It is a good seed producer and makes about twice as much forage as native grasses. Yellow bluestem has a prostrate habit of growth which is ideal for erosion control. The Caucasian bluestem, however, is a tall-growing grass and seems to be adapted to western Oklahoma. The yield from both of these grasses has been about the same as that of native grass. Plantings of Buffalo grass were made with both hulled seed and burrs. The hulled seed germinated readily and developed sod covers in about a third to a half the time required by the burr plantings.

Vegetated Waterways.

Sod-forming grasses are the best plants for lining water channels. Buffalo grass has made a good cover for channels on the Cherokee Station. Bunch grasses and legumes do not provide as dense a soil cover as the sod grasses. But, where the soil is deep and fertile, weeping lovegrass, switchgrass and mixtures of these and other grasses are giving adequate protection for outlet channels on land slopes of two to three percent. Alfalfa is providing a satisfactory protective cover and normal hay crops in channels on the flatter slopes. But, vegetation in water channels should be frequently mowed or systematically grazed for best results.

Cultivation and Fertilization.

Cultivated row plantings of grass produced about two times more seed than broadcast strips. But the broadcast plots produced the best quality of hay. Superphosphate and ammonium nitrate fertilizers were

applied on switch, little bluestem and weeping lovegrass. The hay yields of switchgrass in the 42-inch rows and weeping lovegrass in the 21-inch rows were about doubled by fertilization. Fertilization increased the seed yield of switchgrass approximately 200 percent.

Occasional light disking and fertilization increased the yield of Bermuda grass 110 percent and the bunch grass 36 percent in 1948.

Pasture and Meadow Development and Management - (Working Plan R-1-1-4 (b), Guthrie). These studies consist of removal of brush, reclaiming, seeding and fertilizing eroded land for pasture and meadow. Sprouts and shrubs are controlled with both machines and chemicals.

Machines.

Brush mowers, saws, beaters, crushers and buck rakes have been used on the station at Guthrie. They all gave satisfactory results when used on material within the limits for which each is best suited.

Chemicals.

Ammonium sulfamate (Ammate), 2,4-D and 2,4,5-T were tested. Ammate is not selective, that is, it affects all plants to which it is applied. The 2,4-D's are not affective on all woody species. Best results were obtained when the brush was completely saturated with a spray solution containing about three pounds of acid equivalent per acre.

In 1948, 2,4,5-T acid was applied on oak, hickory, persimmon and mesquite. Oak and hickory appeared to be completely dead when the results were checked in the fall. The growth of persimmon and mesquite was also nearly all dead above the ground but there was some resprouting from the roots. Where a mixed population of plants is encountered, a mixture of 2,4-D and 2,4,5-T acid has given encouraging results.

The best time to apply chemicals appears to be in the spring when the plants are in a green, growing condition.

A heavy stalk-cutter type machine has been used to crush down deadened brush the second and third years after applying the chemicals.

After the brush was removed, grass production was increased about five times. The cleared, virgin land produced an average of 80 pounds of beef per acre during the growing season of 1948.

Making Good Pastures from Eroded Land.

Most of the eroded land, once considered practically useless, can be developed to produce beef and dairy products. But, before this can be done, the lime and phosphate needs for the production of clovers must be met.

Proper combinations of lime, phosphate, legumes and grasses will do wonders for inherently poor soils. During the last two years beef production was increased 124 percent by this system of pasture development.

Goodwell, Oklahoma, H. H. Finnell, Project Supervisor.

Introduction. Soil conservation investigations were continued throughout the Great Plains states, with the exception of Wyoming, in cooperation with state agricultural colleges and experiment stations, the Soil Conservation Service regional offices at Fort Worth, Texas, Lincoln, Nebraska, and Albuquerque, New Mexico, and the Great Plains Agricultural Council.

During the year, negotiations were completed and a memorandum of understanding executed among the Oklahoma Experiment Station, the Panhandle A. & M. College, and the Department of Agriculture, providing for the transfer of this headquarters from the Old Post Office Building, Box 2289, Amarillo, Texas, to Panhandle A. & M. College Campus, Goodwell, Oklahoma, and for the initiation of additional cooperative work plans.

The plainswide collection of field records involves the supervision of 7 field men assigned by Soil Conservation Operations in collaboration with 7 Soil Conservation Research representatives, the district conservationists and work unit technicians in 46 selected Great Plains soil conservation districts out of the 400 or more operating in the Great Plains portion of Regions IV, V, and VI. The special Oklahoma projects which are being planned involve the supervision of the research activities of two of the Panhandle A. & M. College staff members and one who is yet to be employed.

Headquarters for this work are maintained on the third floor of Sewell-Loofbourrow Hall, Panhandle A. & M. College, Goodwell, Oklahoma. The space is furnished to the Service by the Panhandle A. & M. College under the terms of the Memorandum of Understanding previously mentioned.

Field Activities.

Great Plains Soil Moisture Survey and Field Studies. Observation Aids, SP-6, cooperating in this project, are listed with their headquarters as follows:

George T. Williams, Stanley, North Dakota
Merritt E. Anderson, Chamberlain, South Dakota
Ellis M. Baker, Oberlin, Kansas, succeeded by
Oliver R. Nuzum, Osborne, Kansas
V. A. Killerlain, Sterling, Colorado, succeeded
by D. K. Daubert, Littleton, Colorado
R. R. Jones, Clovis, New Mexico
Roy V. Bailey, Perryton, Texas
Olmon W. Sweat, Plainview, Texas

These men were continuously on duty throughout the calendar year of 1948, which is the second full year's work accomplished during the development of this activity. In addition to the changes indicated in the listing of cooperating aids, the replacement of R. R. Jones at Clovis, New Mexico, is now in progress. The transfer of W. R. White of Canon City, Colorado, has been authorized to replace Mr. Jones, who has been promoted to soil conservationist, P-1. Mr. White's headquarters will be moved from Canon City, Colorado, to Clovis, New Mexico. In spite of the changes of field personnel, the observations were carried out without serious interruption, and the total amount of work accomplished compares favorably with 1947. However, due to these changes, and also to the moving of headquarters from Amarillo to Goodwell, the time used during the year by the project supervisor in actual scientific work was greatly reduced.

Service to Districts.

During 1948, a total of 107 reports of current soil moisture and ground cover conditions were prepared and supplied to district conservationists, work unit conservationists and county agents in 46 soil conservation districts. By states, these current land condition reports were distributed as follows:

| | | | |
|--------------|----|------------|----|
| Montana | 6 | Kansas | 12 |
| North Dakota | 6 | New Mexico | 18 |
| South Dakota | 13 | Oklahoma | 11 |
| Nebraska | 6 | Texas | 26 |
| Colorado | 9 | | |

By regions they were divided as follows:

| | |
|-----------|----|
| Region IV | 37 |
| Region V | 43 |
| Region VI | 27 |

Field Records Accumulated.

The sample areas under observation during 1948 comprised 46 selected soil conservation districts. Records were started on 3,017 cultivated fields and 157 pastures during the year. The records completed during

the year were 3,225 on cultivated fields and 155 on pastures, totaling 3,380. Under way on January 1, 1949 were 2,130 records, of which 1,973 were on cultivated fields, 120 on pastures.

Studies of Land Use Experience in the Old Dust Bowl.

The studies of erosion and land abandonment begun in 1946 in southwestern Colorado, southwestern Kansas, the Panhandles of Oklahoma and Texas, in which the field work was completed in 1947, were carried on intermittently throughout 1948. The statistical work and preparation of a report were completed on the Colorado, Kansas and Oklahoma portions of the area. The technical report entitled "Land Use Experience in Southern Great Plains" and a popular summary entitled "Dust Storms Come from the Poorer Lands" have been submitted for publication. The cooperation of the experiment stations in criticizing and clearing this information for publication was outstanding.

The maps and data of sample areas for the northern tier of Texas Panhandle counties are now available. In view of the need for similar studies along the Texas-New Mexico border southward, it is anticipated that this can be combined with an extension of this kind of study which has been proposed for starting as soon as men and funds are available.

Of equal priority to the West Texas-New Mexico area is the Minot area of North Dakota.

Rio Piedras, Puerto Rico, R. M. Smith, Project Supervisor.
(Cooperative project SCS, BPISAE, Insular Experiment Station, Federal Experiment Station)

Summary of Outstanding Developments.

Kudzu.

Rapid improvement has been made in the use of tropical kudzu, both as a forage and as a green manure crop. Considerable information has been obtained as to methods and speed of establishment, yield levels in relation to major soil fertility differences, potential advantages of several different combinations with grasses, and details of management with dairy cows in such a way as to eliminate the need for cut feed as well as to reduce the need for protein in the concentrate. Procedures developed also offer promise for the effective use of kudzu as a permanent green manure in sequences of cultivated crops, both on steep slopes and on bench terraces. The need for high quality legumes on the farm lands of Puerto Rico is tremendous. No single legume can possibly satisfy all of the variable needs, but with proper soil treatment and proper detailed management, our experiences indicate that tropical kudzu seems to have very few weaknesses within its range of

climatic adaptation. We estimate from our present knowledge that the agriculture of Puerto Rico might effectively use as much as 400,000 acres of tropical kudzu, or about 1 acre out of every 5 on the entire Island. Our results help to provide essential information about soil requirements and management which will permit this full use to be realized.

Soil Organic Matter.

The role of soil organic matter and nitrogen in tropical soils has been clarified. There is several times as much organic matter in all of the humid soils of Puerto Rico as was expected by comparison with the southern United States. This fact places great emphasis on the need for holding the top layers of soil in place because the subsoils are relatively low in organic matter and nitrogen. Large differences in growth are associated with obvious soil organic matter differences at Utuado and elsewhere. Soil analyses of the runoff-erosion plots show a close relation between cane yields over a 4-year period and the total nitrogen of the individual plots. This, plus pH differences, explains most of the variations among replicates which have been noted during the history of the plots.

Other organic matter and nitrogen data obtained show that it is practical to rebuild the organic supply in depleted soils or in raw subsoil. Grass and legume covers, mulch, and liquid manure are all shown to be effective in this respect. In one case, repeated manuring has built up the organic matter supply considerably above what would be expected in the original virgin soil.

Sulphur.

Sulphur deficiency has been found in Utuado surface and subsoil and in Mucara subsoil in greenhouse pot tests. An improved method of sulphur analysis was devised to assist in the study of this element, and plant analyses have been completed which show that the deficiency symptoms in velvet beans correspond closely with the sulphur percentage in the plant. These results guide us in treating experimental plots and emphasize the necessity for considering sulphur as an essential constituent in choosing fertilizers.

Soil Physics Laboratory.

We have largely completed the initial phases of providing an effective soil, water, and soil physics laboratory. This includes the assembling, setting up, testing and standardizing of field and laboratory equipment, and the modification of techniques to fit our specific needs. We are now able to carry out several tests to help evaluate soil structure differences; and to provide complete soil permeability and pore

size distribution determinations as well as to make other physical tests. Satisfactory samples for this purpose are being taken with a standard 3" core sampler or with the large mechanical tool built by the Utah Scientific Research Foundation, which takes 4" cores to depths of 6 feet.

Plant Breeding.

Over 200 different grass and legume varieties have been introduced and are being observed in test plots for desirable characters. Cytological and hybridization studies have been undertaken with special emphasis on the kudzu, velvet bean, and cowpea groups, as well as on guinea grass and some of its varieties. It has been found that there is a sharp increase in the production of filled seed with time in several varieties of guinea grass. This is of considerable theoretical interest and it may have great practical value if this information is used in the commercial harvesting of seed. A segregant of tropical kudzu, bearing very much less pubescence on stems and petioles (designated "hairless") has been found and is being tested.

Research Notes.

Near the end of the year we started preparing and releasing short statements called "Research Notes." These notes attempt to explain our latest results, our current viewpoint on a problem, or details of proven practices which might be applied in Puerto Rico. They are primarily intended to give practical help to SCS Operations. They may also be of interest to cooperators in our program as an aid to their understanding and judgment of the soundness of our thinking and of our work.

Clemson, South Carolina, John T. Bregger, Project Supervisor.

Summary Review.

1. By use of double or mutually supporting soil conservation practices (possible only under orchard conditions), a degree of erosion control has been secured in peach orchards unequalled by any other cultivated farm crop. The use of closely spaced terraces and a well "managed" cover crop has prevented both runoff and erosion over a period of eight continuous years (since "100 year rain" of 1940).
2. Importance of adequate fertilization of orchard cover crop has been shown. Rye cover crop yielding 30 tons green weight per acre has provided effective ground cover for entire summer period of high intensity rains.
3. So. spotted bur clover has made best growth of any legumes as reseed-ing winter annual cover crop. (Yield 12-1/2 T/A) In addition to perfect soil protection during winter rains, it has provided nitrogen and shows low seed and management cost.

4. Cover crops can be completely converted into mulches by use of heavy weed cutter (modified cotton stalk cutter weighing 1430 lbs.). Method is more convenient than mowing and cheaper than cultivation. Nothing less than complete utilization of cover crop residues will provide the amount of protection needed to prevent harmful effects of direct rainfall or sprinkling irrigation.
5. Importance of using non-legume species alone or in mixture for orchard cover crops has been demonstrated. Slower breakdown of residues is responsible for greater lasting effects. If legume is used alone, one of the more woody types should be chosen.
6. Mowing has been found significantly superior to cultivation in the subduing of a rye cover crop, both in tree growth and peach yields. (Same principle involved as in rolling down cover crop. Less tying up of nitrates is the probable cause).
7. Inadequate soil protection from the commonly used fall planted winter cover crops has been frequently observed. Summer cover crop residues have been shown to provide better winter protection than the average so-called "winter cover crop" which makes most of its growth in the spring. Such a program also solves the objection raised in some orchard areas that having a live cover crop on the ground in spring will increase frost hazard in contrast to bare ground. (Increased heat radiation).
8. Peach trees under certain continuous cover crops (perennials and reseeding annuals), as well as those under "minimum cultivation" treatments, tend to reach their maximum bearing capacity later than under treatments involving the maximum amount of cultivation or complete mulching. Whereas trees in the latter treatments showed maximum yields of fruit in the seventh season, the non-cultivated trees were still "catching up" in the ninth season.
9. Rotary mower shows promise for clipping tall types of summer weeds in peach orchards. (Superior to cultivation and more economical).
10. Erosion problems under sprinkler irrigation have been observed which closely approach those of heavy summer rains. Evaluation surveys in South Carolina and Washington orchards indicate necessity for low rates of application and presence of a good cover crop or other ground cover when water is applied.
11. Increased interest on part of Operations toward use of orchard cover crops has been shown by their cooperative participation in field tests to convince peach growers of beneficial results.

Clemson, South Carolina, T. C. Peele, Project Supervisor.

Mulch Farming.

Runoff and erosion from corn following winter cover crops of vetch and rye have been much lower where tillage practices designed to retain the plant residues on the soil surface as a mulch were used than where conventional clean tillage methods were used. During the six-year period, 1943-48, the average yearly runoff during the corn growing season from the areas where the mulch tillage methods were practiced was only 3.5 percent as compared with 12.0 percent where the vetch and rye was plowed under and 26.6 percent from areas where no winter cover crop was grown. The average erosion from these areas during the corn growing seasons was 400, 2,400, and 5,400, pounds per acre per year, respectively. The average yields of corn during the 6-year period were 48 bushels per acre from the mulch plots, 47 from the plots where vetch and rye was plowed under and 44 where no winter cover crop was grown.

In other tests where corn follows summer cover crops of Kobe lespedeza or crotalaria spectabilis, the mulch methods have given yields equal to those where conventional clean tillage operations are used.

Mulch methods with oats following Kobe lespedeza decreased runoff and erosion and increased yields in 1948. Where plots were ripped with a Graham Hoeme field tiller the erosion and runoff were about 1/5 of that from plots where the plant residue was plowed under while the yield of oats on the ripped areas was about 1/3 more than that from the plowed plots.

Irrigation.

The use of supplemental irrigation on field corn at Clemson during a 3-year period, 1946-1948, increased the average annual yield in bushels per acre from 84 for the unirrigated plots to 122 bushels for the irrigated areas. The quantity of water applied as irrigation averaged 4.1 inches per year.

Alfalfa plots receiving supplemental irrigation produced 2.30 tons per acre as compared with 1.20 per acre from the unirrigated plots for the first two cuttings. A total of 7.25 inches of water was added as irrigation during the growing periods included in these cuttings. Subsequent yields were greatly reduced due to insect and worm damage on all plots and increases in yields from the irrigated areas were small for the third and fourth cuttings.

The increase of net income from the irrigated over the unirrigated for the four cuttings was \$40.05 per acre, which would probably have been greater if the heavy infestation of insects and worms could have been controlled during the growing season by use of an insecticide which would not affect the hay as stock feed.

Brookings, South Dakota, Ralph A. Cline, Project Supervisor.

Effect of Tillage Practices and Crop Residue Management on Soil Removal by Wind.

Subsurface tillage was the most effective tillage method in preventing soil removal by wind as shown by soil erosion data presented in Table 1. The least effective tillage method was moldboard plowing. Utilizing crop residue on the surface as mulch gave 17 percent greater protection to the soil than when the residue was incorporated with the surface soil by disking. Residue turned under with the moldboard plow gave 38 percent less protection to the soil than stubble mulch. When all previous small grain residue was returned to the soil greater protection from wind erosion was obtained regardless of initial tillage operation. The addition of manure to 6-inch wheat stubble reduced wind erosion on both oneway disked and moldboard plowed land, but increased it slightly on subsurface tilled land.

Table 1.—Effects of Tillage and Residue Treatments on Soil Removal by Wind, 1942-1948

| Wheat stubble left every other year | : Soil removed from corn stubble, lbs./A. | | |
|----------------------------------------|-------------------------------------------|--------|--------|
| | : Subsurface | Oneway | Flow |
| Mowed stubble | 9,038 | 9,492 | 9,382 |
| 6-inch stubble | 6,635 | 9,500 | 9,811 |
| 6-inch stubble and manure | 7,023 | 8,438 | 9,226 |
| 12-inch stubble | 7,261 | 8,168 | 11,487 |
| All stubble | 5,464 | 5,991 | 8,822 |

Effect of Tillage and Crop Residue Management on Crop Yields.

Corn yields from stubble mulch tillage equaled those from moldboard plowing in a corn-wheat rotation as shown in Table 2. Oneway disking produced corn yields slightly lower than the other two tillage methods. An application of 8-tons of manure to 6-inch wheat stubble produced higher corn yields than any of the other residue treatments. The response was greatest when the manure was left on the soil surface. Satisfactory corn stands were more difficult to obtain when the heavier rates of straw were retained on or near the soil surface. Maturity and moisture content of the ear corn was influenced very little by previous tillage or crop residue treatment.

Table 2.—Effects of Tillage and Rates of Straw on Yields, 1942-1948

| Wheat stubble left every other year | : Corn Yields Bu./A. | | | : Wheat Yields Bu./A. | | |
|-------------------------------------------|----------------------|--------|------|-----------------------|--------|------|
| | : Subsurface | Oneway | Plow | : Subsurface | Oneway | Flow |
| Mowed stubble | 55.2 | 49.5 | 51.0 | 27.4 | 28.1 | 29.2 |
| 6" stubble | 49.5 | 48.0 | 49.7 | 28.1 | 27.6 | 28.1 |
| 6" stubble & manure | 53.6 | 51.5 | 52.7 | 29.9 | 31.8 | 30.6 |
| 12" stubble | 48.2 | 48.4 | 48.1 | 27.6 | 28.3 | 28.3 |
| All stubble | 47.3 | 50.4 | 52.7 | 27.4 | 28.6 | 29.2 |

Wheat yields, where the previous seedbed preparation for corn was mold-board plowing, were slightly higher than those where the previous seedbed preparation was oneway disking and subsurface tillage. The residual effect of manure on wheat yields was greatest where the manure had been incorporated with the surface soil by oneway disking. The manured seedbeds not only increased the total grain and straw produced but also increased the test weight of the wheat. The largest quantity of wheat straw was produced where the previous seedbed for corn was oneway disked. Wheat with the highest test weight was produced where the corn seedbed was subsurfaced tilled.

Effect of Grass Sod on Soil Removal by Wind.

Soil losses for this study as measured by the wind tunnel are reported for the first time since 1945. This is also the first year that soil erosion data was obtained from land returned to cultivation in the fall of 1945 after 4 years in grass. The 4-year grass land, after three years of cultivation, lost approximately the same amount of soil as the 2-year grass land in cultivation for the past 5 years as shown in Table 3. Land retired to grass 2 and 4 years each, lost approximately one ton more soil than the 3-year grass land. Land 2 years is crested wheatgrass, after 5 years cultivation, lost 44 percent less soil than land where grass was excluded from the rotation. Land retired to western wheatgrass for 2 years, lost 47 percent more soil per acre after 5 years of cultivation, than crested wheatgrass land under the same treatment. A fibrous rooted bunch grass (crested wheatgrass) offered more resistance to wind erosion than a coarse rooted sod forming grass (western wheatgrass).

Effect of Grass Sod on Crop Yields.

The largest corn yields were produced where grass was included in the rotation as shown in Table 3. Corn following grass developed larger stalks and ears and was more mature at time of harvest than corn on non-grass land. Increased vigor was shown throughout the growing season by corn following grass. Corn yields were generally larger following crested wheatgrass than those following western wheatgrass.

Table 3.—Effects of Grass on Yield and Soil Removal by Wind

| Previous crop | Years in Grass | Soil eroded from corn stubble, '48 lbs/A. | Corn Yields Bu/A. | Wheat Yields Bu/A. |
|--------------------|----------------|-------------------------------------------|-------------------|--------------------|
| Crested wheatgrass | 2 | 13,089 | 52.1 | 31.3 |
| Western wheatgrass | 2 | 24,604 | 53.8 | 30.6 |
| Crested wheatgrass | 3 | 15,730 | 53.9 | 30.0 |
| Western wheatgrass | 3 | 18,528 | 49.4 | 30.0 |
| Crested wheatgrass | 4 | 17,283 | 54.7 | 26.7 |
| Western wheatgrass | 4 | 21,060 | 54.1 | 27.3 |
| Cont. corn-wheat | None | 23,528 | 50.7 | 30.6 |

Wheat yields following 2 years of grass were practically the same as the continuously cropped land. Wheat yields were generally depressed immediately following 3 and 4 years of grass. After the first year of cultivation, land retired to 3 and 4 years of grass generally outyielded the non-grass land. Wheat having the highest test weight was produced on land retired to 4 years of grass. Crested wheatgrass land produced the highest average test weight per bushel. The largest quantity of straw was produced on the 3-year grass land. Western wheatgrass land produced slightly larger straw yields than crested wheatgrass land.

Tillage and Residue Trials, Central Substation, Highmore, South Dakota.

In a sorghum-wheat-oats rotation, sorghum forage yields were highest on moldboard plowed land as shown in Table 4. Wheat on a disked seedbed produced slightly higher yields where the previous seedbed for sorghum was subsurface tilled. Oats on a subsurface tilled seedbed yielded more where the seedbed for sorghum was moldboard plowed. The application of manure, once in the rotation before sorghum, increased production more than returning all or part of the previous crop residue. The residual effect of the manure on wheat yields was greater on subsurface tilled land than on moldboard plowed land. Considerably larger oat yields were obtained on manured land moldboard plowed for sorghum than on manured land subsurfaced tilled for sorghum, all other treatments being the same. Oat yields and sorghum forage yields on moldboard plowed land were decreased when all the previous crop residue was returned to the soil.

Subsurfaced tilled land produced a larger yield of sorghum forage in a sorghum-wheat rotation than subsurface tilled land in a sorghum-wheat-oats rotation. In the 2-year rotation forage yields from subsurface tilled land were slightly less than forage yields from moldboard plowed land in the 3-year rotation. Wheat yields, from the 2-year rotation, are comparable to those produced from the 3-year rotation. Sorghum forage and wheat yields from manured land in the 2-year rotation were comparable to those from moldboard plowed, manured land in the 3-year rotation. In the 2-year rotation forage yields decreased as the amount of residue returned to the soil was increased.

Subsurfaced tilled summer-fallow produced larger wheat yields than the 2 and 3-year rotations. As in the other rotations, wheat yields were increased by the manure treatment. Response to manure on summer-fallow appeared greatest in the more favorable years. No appreciable difference in wheat yields resulted when all or only part of the previous crop residue was returned to the soil.

Table 4.--Effects of Rotations, Tillage and Straw Residues on Crop Yields, Central Substation, Highmore, South Dakota

| Crop | Seedbed Preparation | Yields, Bu/A. | | |
|--------------------------------|-------------------------------|---------------|-------------------|-----------|
| | | 6" straw | 6" straw & manure | All straw |
| Sorghum-wheat-oats rotation | | | | |
| Sorghum | Flowed | 4,506 | 4,730 | 4,477 |
| | Stubble-mulched ^{1/} | 3,486 | 3,636 | 3,643 |
| Wheat | Disked | 21.3 | 22.4 | 21.9 |
| | Disked | 21.4 | 22.9 | 22.3 |
| Oats ^{2/} | Stubble-mulched | 56.0 | 60.3 | 55.9 |
| | Stubble-mulched | 52.5 | 55.8 | 48.7 |
| Sorghum - wheat rotation | | | | |
| Sorghum | Stubble-mulched | 4,308 | 4,723 | 4,140 |
| Wheat | Disked | 21.0 | 22.2 | 21.7 |
| Summer fallow - wheat rotation | | | | |
| Wheat | Stubble-mulched | 23.2 | 24.3 | 23.4 |

^{1/} Average 6-year period (1943-1948)

^{2/} Average 6-year period (1942-1948)

Amarillo, Texas, Charles J. Whitfield, Project Supervisor.

Stubble Mulch Management for Water Conservation and Erosion Control in the Southern Great Plains.

The grain yields for the 7-year period from 1942 through 1948, along with the 7-year average for plots in wheat year after year are given in Table 1.

Table 1.--Grain Yields from Stubble Mulch Plots in Continuous Wheat, 1942 through 1948

| Tillage | Wheat yield - Bushels per Acre | | | | | | | 7-year Average |
|----------------|--------------------------------|------|------|------|------|------|------|----------------|
| | 1942 | 1943 | 1944 | 1945 | 1946 | 1947 | 1948 | |
| Moldboard plow | 20.3 | 4.2 | 19.7 | 4.4 | 1.8 | 31.8 | 5.6 | 12.5 |
| Cneway | 20.1 | 6.0 | 24.5 | 6.3 | 2.6 | 28.4 | 4.6 | 13.2 |
| Subtillage | 19.0 | 7.1 | 26.4 | 6.9 | 6.0 | 34.3 | 6.2 | 15.1 |

These results show an average of 2.3 bushels more wheat per acre from sub-tilled plots than from plowed plots. Analysis of variance showed these differences on grain yields to be highly significant between these two types of implements. On the other hand, there was no significant difference in grain yields between the two sub-tillage machines, the Noble cultivator and the Station machine; also, there was no significant difference in yields between the oneway and the moldboard plow.

Where two implements, the oneway and the subtiller were used on plots planted to wheat one year and fallowed the next year, an increase of 1.4 bushels per acre was recorded in favor of the sweep machine over the oneway (Table 2). Analysis of variance indicates this difference to have a high degree of significance. Average yields with fallowing were somewhat lower than with continuous wheat during the period of study. For a single year, however, wheat after a year of fallow produces more than wheat after wheat. This effect is very pronounced in dry years, and has meant the difference between crop success and failure, just as the maximum retention of residues on the surface has done.

Table 2.—Grain Yields from Stubble Mulch Plots in Wheat and Fallow, 1942-48

| Tillage | 1943 | 1944 | 1945 | 1946 | 1947 | 1948 | 6-year Average |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|----------------|
| Oneway | 11.9 F | F 28.4 | 16.7 F | F 8.5 | 33.1 F | F 13.9 | 9.4 |
| Sub-Tillage | 14.6 F | F 28.4 | 20.4 F | F 13.9 | 36.8 F | F 15.7 | 10.8 |

Nitrate Nitrogen.

On the continuous wheat plots, nitrates were lower on subtilled than oneway plots. Fallowing increases nitrates; and in general, nitrates were lower on continuous wheat than on wheat-fallow rotation. This appears to be true where moisture is available for nitrification, and there are no crops to take up the nitrates. In all probability in the relatively dry area of the Southern High Plains, moisture is the limiting factor in crop production, rather than fertility.

Organic Matter.

Organic matter determinations showed higher percentages in stubble mulch tillage when compared to the conventional oneway method of tillage, although the differences were not large. Also, wheat after wheat plots were somewhat higher in organic matter than were the plots in wheat-fallow rotation.

Cover Crops for Erosion Control.

Along with grass and wheat, winter legumes appear to have possibilities as soil conserving and soil building crops in the Southern High Plains. Two winter legumes, hairy vetch and Austrian winter pea, were tried on the Amarillo Station this past year. Plantings were made on two dates, October 15 and November 15, 1947. In spite of severe winter conditions, both species made sufficient growth to give late spring protection. Clippings made on June 7, 1948 showed that more green forage was produced with the October planting:

| <u>Crop</u> | <u>Date of Planting</u> | <u>Forage production Lbs. per Acre, Green weight.</u> |
|---------------------|-------------------------|---------------------------------------------------------------|
| Hairy vetch | Oct. 15, 1947 | 3,000 |
| Hairy vetch | Nov. 15, 1947 | 2,000 |
| Austrian winter pea | Oct. 15, 1947 | 3,000 |
| Austrian winter pea | Nov. 15, 1947 | 1,000 |

Weather and Crop Production.

Climatic conditions during the 1948 season in general have been about what can ordinarily be expected with the exception of precipitation, which was above average. The total precipitation was 20.38 inches, which is 2.23 inches above the 10-year Amarillo Conservation Experiment Station average of 18.15 inches. The average hourly wind velocity was 7.0 miles per hour. There were 23 wind storms, of which 6 were classified as dust storms. The average of daily maximum and minimum temperatures was 57.3 degrees with a maximum of 104 degrees and a minimum of minus 1 degree. Atmospheric humidity for the year averaged 59.4 percent. The 1948 growing season was 187 days with the last killing frost in the spring on April 13, and the first killing frost in the fall on October 18.

Livestock and Pasture Studies.

Gains. A summary of gains made by weaner steer calves in the winter, and yearling steers in the summer, are given in Table 3. The response of the animals to the pasturage was about the same as in past years, with better gains from seeded areas. The one exception in the 1947-1948 tests was on Sudan, where due to the heavy summer rains this crop grew rapidly and made considerable foliage with a low protein content.

Table 3.--Summary of Gains of Steers from November 1, 1947 to April 1, 1948

Wintered Nov. 1, 1947 to April 1, 1948 on Pasture H, with
2 pounds cottonseed cake daily:

| | |
|----------------------------------|------------|
| Weight at Purchase, Nov. 1 | - 410 lbs. |
| Weight Apr. 1 | - 555 lbs. |
| Average daily gain for winter | - .95 lb. |

Summer gains, pounds per day:

| <u>Lot on seeded pasturage</u> | <u>Lbs.</u> | <u>Lot on Pasture H</u> | <u>Lbs.</u> |
|--------------------------------|-------------|-------------------------|-------------|
| April on Crested Wheat | 2.66 | (Grasses and | 1.75 |
| May on Wheat | 3.23 | | 2.42 |
| June on seeded mixture | 2.16 | Lake Weeds) | 2.32 |
| July on Sudan | 1.31 | | 2.25 |
| August on Sudan | 1.79 | | 1.10 |
| September on Sudan | 1.44 | | 2.59 |
| Aver. for 180 days | 2.10 | | 2.07 |

Weight

| | | |
|----------------|------|------|
| April 1 | 555 | 555 |
| Sept. 28 | 933 | 927 |
| Gain, 180 days | 378 | 372 |
| Daily gain | 2.10 | 2.07 |

Forage Production.

Carry-over was relatively high for all species in 1948, giving good protection to pastures through the winter and spring months. During 1948 total growth of most grasses was good to excellent, thus providing good cover and good livestock gains.

Table 4.--Forage Yields for Different Grasses - Pounds per Acre Clipped

| <u>Pasture:</u> | <u>Grass</u> | <u>:3/18/48</u> | <u>:3/18-12/13</u> | <u>:12/13/48</u> |
|-----------------|-----------------------------------------------|-----------------|--------------------|------------------|
| F | Western wheatgrass | 1,103 | 742 | 1,452 |
| H | Blue grama and buffalograss | 462 | 513 | 574 |
| H | Western wheatgrass | 1,147 | 878 | 1,485 |
| I-1 | Blue grama and buffalograss | 178 | 716 | 837 |
| I-2-E | Blue grama, buffalo and western wheatgrass | 943 | 742 | 1,151 |
| I-2-W | Blue grama, buffalo and western wheatgrass | 1,410 | 972 | 1,620 |
| I-4 | Crested wheatgrass | 1,210 | 641 | 1,012 |

Range Cover Evaluations

Studies were initiated to determine the protective values of different range covers. Preliminary results indicate that an excellent range generally provides a better protective cover than a poor range; however, some of the weeds that may cause a site to be classed as poor can provide very good protection to the soil at the season of their maximum growth. Because of this it is possible for some of the poorer range classes to provide greater protection than some of those classed as excellent, especially during short seasons of the year. From this it seems probable that since the condition classes of poor, fair, good and excellent are based largely on composition of the present vegetation, there is room for considerable variation in the protective cover within each class.

Spur, Texas, R. E. Dickson, Project Supervisor.

Summary of Soil and Water Conservation Research by the Texas Agricultural Experiment Station in cooperation with Soil Conservation Service Research at Spur, Texas.

Water and soil conservation studies were continued on small control plats to determine runoff and soil losses, 17 large cultivated field areas of croplands, and 32 native grassland pastures. Methods of conserving the water and soil include contour cultivation, terracing, flooding and water spreading, tillage, fallow, plant residues, and removal of undesirable brush plants on native grassland. Measurements were obtained on runoff, erosion, depth of moisture penetration and its utilization by plants, crop yields, utilization of forage and livestock gains.

Conserving rainfall by increasing the absorption and penetration into the soil has markedly increased crop yields, reduced soil erosion and helped stabilize production in the region. For each inch of available moisture stored in the second and third foot sections of the soil at planting time the yield of lint cotton has been 101 pounds over an 18-year period. Retention of the water from a 3.86 inch torrential rain on closed level terraced areas increased the yield of cotton 76 percent. Contour cultivation alone increased yields only 16 percent when compared with cotton grown on rows up and down the slope. The value of the annual increase in cotton from the use of closed level terraces has been \$11.19 per acre for a 22-year period. Flooding of heavy fertile soils that are droughty raised the yield of lint from 85 to 174 pounds, wheat yields from 4 to 22 bushels and steer gains on native grass from 131 to 210 pounds per head. Tillage studies on terraced wheatland show that listing on the contour extended penetration of moisture from 14 to 20 inches over the conventional onewaying method. Heavy application of sorghum litter and farm manure, at 20 tons per acre doubled the yield of lint cotton and markedly increased the penetration and storage of water in the soil. Even greater

response was obtained on native buffalo grass from use of 1.5 to 3 tons of clover straw, sorghum litter and farm manure. Commercial fertilizers did not increase the yield of grass.

Moderate stocking of native grass pastures during the summer increased steer gains from 77 to 146 pounds per head, resulted in deeper penetration of moisture and heavier vegetative cover but did not influence acre gains when compared with heavy stocking. Rotation grazing did not increase steer gains or improve vegetative cover. Contour listing increased gains of steers 22 percent over a 7-year period on moderately stocked pastures with a predominance of buffalo grass. Removal of a moderate stand of mesquite brush from native grass pastures increased acre gains 43 percent in 1948 and an average of 15 percent over a 4-year period.

Control of mesquite by applying 2,4-D and 2,4,5-T solutions to the foliage with ground and airplane equipment has been moderately effective under favorable conditions in destroying the above ground growth of trees and sprouts but less than 5 percent of the plants have been killed. Long periods of moist contact of chemical solutions with the leaf and tender stem tissues are needed to obtain adequate absorption and translocation to dormant sprout buds on the underground stem. Newly developed formulations of 2,4-D and 2,4,5-T and other chemicals offer considerable promise of effectively controlling mesquite at low cost. In addition to horses, cattle and sheep, it has been found that coyotes and jack rabbits disseminate viable seed of mesquite.

Temple, Texas, J. R. Johnston, Project Supervisor.

Legumes and small grain are effective in reducing water erosion damages.

Hubam sweetclover, alfalfa, and winter oats are quite effective in reducing soil and water loss from cropped land in the Texas Blacklands. Oats and sweetclover have about equal value for lowering runoff and erosion while these crops are growing on the land. The residual effect of the sweetclover is considerably greater than that of the oats. The average annual soil loss from 4-percent Austin clay in a cotton, oats rotation was 8.76 tons per acre; for a cotton, hubam rotation this loss was 4.70 tons per acre per year.

Hubam sweetclover in rotation with cotton and corn is now an accepted practice in Texas Blacklands.

Although the past two years have been unfavorable for this practice, it has not discouraged farmers in its use. No small part of the increased yield of cotton following sweetclover is brought about by control of the root rot disease.

Winter grain and biennial sweetclover for the Texas Blacklands.

Planting these crops together with phosphate fertilization is the outstanding agronomic development for this area in recent years. Two years' of work have shown that this mixture, when properly fertilized, can be used in a number of ways. It is an excellent soil conservation measure; it is outstanding for soil improvement; the mixture is a good forage and grain producer; and it fits perfectly into crop rotations with cotton and corn.

Phosphate fertilizer becomes important factor in conservation of Texas Blacklands.

Sweetclover and winter oats growing in soils of the Texas Blacklands respond favorably to phosphate fertilization. These crops are the most valuable ones we have for cultivated land insofar as erosion control is concerned. Phosphate fertilization of sweetclover increases growth 25 to 700 percent, depending on the fertility of the soil and the degree of erosion. Winter hardiness and yield of winter oats is increased by phosphate fertilization. Eroded soils of low fertility give greater response to phosphate than the better soils.

Livestock utilization of grasses and legumes used in conservation farming.

Even though the 1948 year was unfavorable insofar as temperature and rainfall are concerned the livestock grazing work continued to be in high demand by farmers and ranchers of the area. The use of more grasses and legumes in the cropping systems of this area is necessary before an adequate vegetative program can be attained for good soil and water conservation. The use of winter grain and biennial sweetclover mixtures holds exceedingly great promise for erosion prevention, soil improvement, and excellent forage production. The use of waste areas along streams and grassed waterways for sod grasses and pasture legumes is gaining in favor with farmers for two reasons: (1) Excellent pasturage is provided, and (2) Excess water disposal is less hazardous when there is a good grass sod present to prevent soil cutting by flowing water. Use of Class III and Class IV land for tall grasses such as K R bluestem, little bluestem, and Johnson grass is gaining in popularity with farmers and ranchers. Much more of this type land should go into tall grasses and will do so when the landowner realizes there is more profit in this method than there is in row cropping with cotton or corn.

Surface management of crop residues in Texas Blacklands.

Four years results show that management of plant residues on the land surface in the Texas Blacklands does not reduce soil and water loss. Shallow tillage necessary for management of plant residues on the soil surface encourages Johnson grass, making control of this pest quite difficult.

Blacksburg, Virginia, T. W. Edminster, Project Supervisor.

Determination of the Effect of Slope, Character of Soil, Rainfall and Cultural Practices on Erosion from Cropland.

Under contour cultivation and simulated stubble mulch the soil and water losses showed a definite relationship to the degree of slope. On the "up and down hill" plots, this relationship was not pronounced. It appeared that when water was allowed to flow from the land without impedence such factors as soil infiltration capacity, permeability, etc. overrule the slope effect.

Preliminary analysis of the original 10 years of control plot data has been started. Rainfall, runoff and soil loss and plant food loss data were checked and then analyzed on a probability basis. Steps are being taken to complete this analysis for an Extension Station bulletin to be published in 1949.

Stubble Mulch.

The past five years of study have finally established the fact that under Virginia climate and crop conditions, it is necessary to completely invert the sod layer to a depth of about 3 inches, and, in the same operation, subtile to an additional depth of 4 or 5 inches. This inversion of the sod layer is necessary in order to attain a satisfactory kill of the sod plants. Two to four weeks after this tillage operation about one half of the dead vegetative material can be brought back to the surface by harrowing the area twice with a spring tooth harrow. Seeding and cultivating can then be done with conventional equipment. Therefore, an effective control of the regrowth of the perennial sod grasses and clovers has been found. This mulch cover, by observation, reduces runoff and erosion losses from cultivated crops to less than 1/4 of that occurring under present tillage practices.

There are still several problems which will require further study. Germination of seed in the mulched areas still runs 10 to 15 percent below that on the clean tilled plots. Plant food availability throughout the growing season is somewhat different in the mulch plots. Further experiments are being planned to study out solutions to these problems.

Small Grain Stubble Mulch.

Many of the problems encountered in applying stubble mulch tillage to cultivated crops were also encountered in this study; i.e. perennial regrowth, excessive weed growth, plant nutrient deficiencies and poor seed germination.

The yields obtained with the mulch drill on lespedeza sod were about 30 percent lower than those obtained from check plots seeded by conventional practices. However, when applied on corn stubble land there was no significant difference in yields.

No significant difference resulted from the comparison of the machine with and without press wheels. Good rains following seeding eliminated any advantages that compaction may have otherwise shown. Over a variety of conditions the use of press wheels is expected to prove beneficial in promoting good seed germination.

Top dressing of mulch treatments with NO_2 in the early spring definitely improved yields. Further study on rates of application are planned.

At the present stage of this study, there are two applications of this practice that seem logical in spite of the depressed yields that have thus far been encountered. It will enable farmers to produce an additional crop of grain from land which is left in lespedeza for two years. It provides a means of establishing a winter cover crop of small grain, on land that is ordinarily left bare, with a minimum of time and labor. The grain can then be used as a nurse crop for spring seedings of legumes; or grazed and harvested as grain, or it can be turned under in the spring as a green manure crop.

Deep Lime Placement.

Three field studies were installed in Eastern Virginia to study the effect of deep tillage (subsoiling) together with subsoil applications of limestone and other materials upon soil permeability and drainage in soils having impermeable or plow-sole layers above the 18" depth.

Results are not yet available from this project.

Laboratory studies.

Detailed laboratory studies on the stubble mulch project brought out a number of interesting and significant results. It was found that the nitrogen supply of this particular soil on which the test was run was at a sufficient level for optimum yields. This was evidenced from the high yields, lack of response to nitrogen applications on the check plots and to the increase in supply of total nitrogen.

The mulch treatment decreased nitrate nitrogen production, particularly during the early part of the growing season. The percent nitrogen in the harvested corn plants was higher in the checks than in the mulch plots. Application of NO_2 increased the nitrogen content of the crop on both mulch and check plots. The late application gave better response both in yield and % N in the crop than did the earlier applications.

Preliminary analysis of the laboratory data on the Runoff Control plots shows that the rate of depletion of the soils supply of the several nutrient elements was more nearly a linear function of slope than were losses of total nutrients in the soil. Losses increased rapidly with increasing slope.

Laboratory facilities were also provided for the farm pond studies including such specialized equipment as a multiple unit soil permeameter, soil compaction equipment, etc. Facilities were also provided for all determinations involved in the state-wide soil permeability studies.

Pullman, Washington, Glenn M. Horner, Project Supervisor.

Summary.

The erosion control investigations in progress are applicable to the wheat producing section of eastern Washington and the adjacent parts of Idaho and Oregon. Heavy precipitation during the winter and spring of 1947-48 caused severe erosion losses and flood damage throughout the area. The amount of runoff and erosion was closely associated with such factors as plant cover, crop rotations, and crop residue utilization.

Plant cover.

Almost complete control of runoff and erosion was obtained where the soil was protected by wheat stubble, alfalfa and grass, or sweetclover and grass. Fall plowing wheat stubble land also gave an effective degree of control. The critical erosion problem occurred on land seeded to winter wheat. Summer fallowed land in wheat had nearly four times as much erosion as land previously in alfalfa and grass or sweetclover and grass. Pea land seeded to wheat lost less than one-half as much soil as the fallow.

Crop rotations.

The effectiveness of rotations depended on (1) the amount and nature of plant cover on the soil during the winter period, (2) the proportion of land cropped to winter wheat, and (3) the maintenance of organic matter and improvement of soil structure. A rotation of alfalfa and grass in combination with wheat and peas was the most effective for erosion control. Other rotations in order of decreasing effectiveness are: (1) sweetclover and grass for green manure-winter wheat-peas-winter wheat, (2) winter wheat-peas for green manure, (3) winter wheat-Hubam clover for green manure, (4) winter wheat-peas for seed, and (5) winter wheat summer fallow.

Crop production was maintained at the highest levels in those rotations that gave the best erosion control. Wheat grown in rotation with alfalfa or sweetclover produced 37 percent more grain than that grown following peas or summer fallow.

Soil organic matter was maintained only with those rotations that included a legume as a green manure crop. The maximum increase in organic matter was obtained on land cropped to the alfalfa or the sweetclover rotations. A loss of organic matter occurred on land cropped to wheat and summer fallow or wheat and peas for seed.

Crop residue utilization.

A mulch cover was the most effective means of reducing erosion losses from land seeded to winter wheat. For wheat after summer fallow, the treatment consisting of subsurface tillage with the application of two tons of wheat straw per acre lost 3.4 tons of soil per acre compared with 40.7 tons where the same amount of straw was plowed under with a moldboard plow. A light mulch produced with one ton of straw lost 18.4 tons of soil. With moldboard plowing and no straw returned, the soil loss was 66.3 tons per acre.

The number of tillage operations required for the preparation of a seedbed, where sweetclover was utilized as a mulch, was greatly reduced by mowing the clover before it reached the budstage. Clover cut when 30 inches high, together with the regrowth, had smaller stems and permitted a delay in the subsurface tillage operations until the soil moisture content was reduced sufficiently to secure a complete kill of the plants. The smaller stems were more easily broken up during the seedbed preparation.

Morgantown, West Virginia, Earle D. Matthews, Project Supervisor.

Summary.

Little progress in research can be reported from this station during 1948. The station was without personnel until October. All working plans were on an inactive basis before that date.

R-1-1-4.

Working Plan No. R-1-1-4, entitled "The effect of contour pasture furrows on the conservation of soil and water" was recommended for termination on December 2, 1948. No results had been obtained on this project for some years, and it was felt that the objectives had already been attained.

R-1-1-6.

This working plan, entitled "Reclaiming eroded soils," has remained active in that the original field plot layouts, both for timber and agronomic crops, have been continued by the West Virginia Experiment Station. Although there are no 1948 results as far as SCS research is concerned, prospects are bright for obtaining some substantial results in 1949.

A paper entitled "Comparison of subsoils and surface soils in the greenhouse as an aid in understanding and reclaiming eroded soils" has been prepared by R. M. Smith and G. G. Pohlman. No definite plans for publication have yet been made. The significant results summarized in this paper have been previously reported by R. M. Smith.

R-1-2-1.

This project, entitled "The influence of organic matter treatment, type vegetation, cropping system, and cultural treatment upon soil structure as related to erosion control" has been practically inactive in 1947 and 1948. The concrete bin plots have been maintained, but only partial results are available for 1947 and none for 1948. It is thought that this project should be re-examined with the thought of either drastic revision or discontinuation. No decision has yet been reached.

R-1-2-4.

The project, "The physical and chemical properties of selected soil profiles and the root development of vegetation commonly found on them in relation to infiltration and erosion" has been inactive during most of 1948, with the exception of the field trial "Fertilizer treatments to prolong the life of alfalfa stands for the control of erosion on hill lands." Stands counts and soil samples were taken on some plots in 1948, but analyses are incomplete and no conclusions can be reported. This trial, however, shows promise of good results in 1949. Revision of this plan has been recommended.

La Crosse, Wisconsin, H. O. Anderson, Project Supervisor.

Summary.

A. Spencer area, poorly drained soils, North Central Wisconsin.

The primary purposes of this study are to determine (1) probable economic returns from the various grades of land, (2) profitable combinations of land, labor and resources, and (3) economy of land clearing, drainage and soil and water conservation practices. Data were obtained in 1948, as to drainage, land clearing,

terracing and contour strip cropping on these farms. These data have not been summarized to date. The effect of these land improvements on production will be studied during the next few years.

B. Sandy soils area of Central Wisconsin.

Differences between the sand and sandy loam farms in oats and corn silage yields during the past four years, especially were large. Corn stunted by drought, producing little or no ear corn, usually is ensiled or cut for fodder with the result that differences in yields of silage are greater than for corn harvested as grain. Because of the greater tendency to droughtiness, this condition is more prevalent on sand than on sandy loam. There was less difference between sandy loam and sand farms in hay yields than in yields of corn and small grain.

Yield comparisons, average 1944-47

| | Sand | Sandy loam | Difference | |
|---------------|---------|------------|------------|----|
| | | | Units | % |
| Corn..... | 29 bu. | 35 bu. | 6 bu. | 21 |
| Oats..... | 21 bu. | 32 bu. | 11 bu. | 52 |
| Rye..... | 11 bu. | 11 bu. | 0 bu. | — |
| Wheat..... | 13 bu. | 19 bu. | 6 bu. | 46 |
| Potatoes..... | 90 bu. | 91 bu. | 1 bu. | 1 |
| Hay..... | 1.4 ton | 1.6 ton | .2 ton | 14 |
| Silage..... | 4.3 ton | 6.6 ton | 2.3 ton | 54 |

The sandy loam farms averaged 115 acres of cropland and 26.3 units of productive livestock as compared with 117 acres and only 20.5 livestock units for the sand farms. The greatest advantage in livestock production of the former group was in dairying. The greater number of productive livestock units on the sandy loam is an indication of its greater livestock carrying capacity than of sand farms. Feed purchases averaged about \$30 per animal unit for both groups of farms. On the basis of home grown feed, the sandy loams carried 31 percent more livestock per crop acre than did the sand.

Livestock production comparisons, average 1944-47

| | Sand | Sandy loam | Difference | |
|------------------------------------------|------------|-------------|------------|----|
| | 63 records | 103 records | Units | % |
| Productive livestock units ^{1/} | 20.5 | 26.3 | 5.8 | 28 |
| Livestock units per 100 acres | 17.5 | 22.9 | 5.4 | 31 |
| Butterfat, lbs. | 2843 | 3640 | 797 | 28 |
| Hogs, cwt. | 38.9 | 43.3 | 4.4 | 11 |
| Eggs, dozen | 1709 | 1617 | -92 | -5 |
| Feed purchased per an. unit | \$30 | \$29 | -\$1 | -3 |
| Feeding efficiency | \$152 | \$168 | \$16 | 9 |
| Butterfat per cow, lbs. | 273 | 261 | 12 | -4 |

^{1/} One dairy cow, 2 head of young dairy cattle, 1500 lbs. of hogs, 100 hens or 7 sheep equals one productive livestock unit.

The lower level of production and gross income on the sand farms was not offset by lower costs. The average annual gross farm income on the sandy loam farms for the four-year period was almost \$1700 greater than that of the sand farms, whereas total expenses were only slightly more than \$700 greater. Net earnings to the farm operator were \$990, or 57 percent, greater on the sandy loam farms. The net farm income per acre of cropland for this group of farms was nearly double that of the sand group. It is interesting to note that total labor, power and machinery costs are but slightly higher on the sandy loam farms, \$1535 as compared with \$1428. If these costs are applied in total to the feed produced, it shows it costs much less per pound of nutrients on the sandy loam than on the sand farms.

Income, expenses and operator's labor earnings, average 1944-47

| | Sand | Sandy loam | Difference | |
|-------------------------------|--------|------------|------------|-----|
| | | | Units | % |
| Gross income | \$5564 | \$7260 | \$1696 | 30 |
| Farm expense | 3832 | 4538 | 706 | 18 |
| Operator's labor earnings | 1732 | 2722 | 990 | 47 |
| Net farm income ^{1/} | 1459 | 2643 | 1184 | 81 |
| Net farm income per acre | 12 | 23 | 11 | 92 |
| Interest earned on investment | 11 | 15 | 4 | 36 |
| Power and machinery costs | 686 | 812 | 126 | 18 |
| Labor | 742 | 723 | - 19 | - 3 |

^{1/} Operator's labor valued at \$60 per month in 1944 and 1945 and \$80 in 1946 and 1947.

Adequate volume of business is important on light soils as well as elsewhere, but cultivating an unlimited acreage of the lightest soil does not make it an economic unit. Farmers on these lighter soils are handicapped as compared with farmers on better land. It should

be kept in mind that this study to date was for a four-year period of unusually favorable prices and weather conditions and that farm record cooperators are usually considered to be better farm managers than the average. Judging by the data obtained in this study, net farm incomes under average conditions on these lighter soils probably are below the level that may be considered satisfactory.

Operator's labor earnings, 1944-47, inclusive

| Acres in cropland | Sandy loam farms ^{1/} | | Sand farms ^{1/} | |
|-------------------|--------------------------------|----------|--------------------------|----------|
| | Ave. acreage | Earnings | Ave. acreage | Earnings |
| Over 100 acres | 141 | \$3100 | 151 | \$2300 |
| Under 100 acres | 75 | 2300 | 71 | 1110 |
| Under 75 acres | 55 | 1745 | 58 | 590 |

^{1/} Cropland on sand farms consists chiefly of Plainfield or Coloma sand.

Cropland on sandy loam farms averages about class IV and III capability.

If \$2000 could be considered a satisfactory net operator's income in 1944 and 1945 and \$2500 in 1946 and 1947, about one-half of the sandy loam farms with over 100 acres of cropland provided adequate income, as compared with one-fourth of the sandy loams with less than 100 acres of cropland. Only one in every seven of larger sand farms provide adequate income and none of the farms with less than 100 acres of cropland reached the above standard. Thus it would seem that the proportion of sand farmers with satisfactory incomes during normal times must be very small - regardless of the size of the farm.

That more hay crops affect crop yields, favorably, is indicated by the 13 percent higher crop yields on sandy loam, on the farms that averaged 38 percent of the cropland in hay than the average yields for farms averaging 28 percent hay land. On sand, crop yields were 7 percent higher with the greater proportion of hay than where less hay was raised.

Percentage of hay and crop yield index with equal fertilizer applied

| | No. records | % hay | Fertilizer application per acre | Crop yield index |
|-------------------------|-------------|-------|---------------------------------|------------------|
| <u>Sandy loam farms</u> | | | | |
| High percentage of hay | 41 | 38 | 69 lbs. | 114 |
| Low percentage of hay | 41 | 28 | 67 lbs. | 101 |
| <u>Sand farms</u> | | | | |
| High percentage of hay | 22 | 40 | 85 lbs. | 92 |
| Low percentage of hay | 22 | 25 | 82 lbs. | 86 |

On the sandy loams, crop yields on farms with the heavier applications of fertilizers were about 17 percent greater than were the yields on similar farms with smaller fertilizer applications. On sand farms, yields were 25 percent greater with the heavier fertilizer applications than with slighter applications.

Crop yield index, farms grouped according to fertilizer applications

| | No. | % | Fertilizer | Crop |
|-----------------------------|---------|-----|-------------|-------|
| | records | hay | application | yield |
| | | | per acre | index |
| <u>Sandy loam farms</u> | | | | |
| High fertilizer application | 41 | 35 | 110 lbs. | 122 |
| Low fertilizer application | 41 | 34 | 36 lbs. | 104 |
| <u>Sand farms</u> | | | | |
| High fertilizer application | 27 | 32 | 131 lbs. | 95 |
| Low fertilizer application | 27 | 33 | 36 lbs. | 76 |

C. Dane County Soil Conservation Benefits Study.

A study was made in the Dane County Soil Conservation District of crop, livestock and miscellaneous production and gross income of two groups of farms that differ mainly in the extent to which needed soil conservation practices had been applied on the land. The nine farms that were classified as "soil conserving" scored 87 percent in application of soil conservation practices and the eight non-soil conserving farms averaged 64 percent. The two groups of farms were quite comparable as to size of farm, acreage in crops and in the proportion of the various classes of land.

Insofar as these records indicate, there was but little immediate change in total production and income as the result of the adoption of a soil conserving program on these farms. Advantages in production and income on the soil conserving farms over a longer period of years will increase more or less in proportion to the effectiveness of the soil conservation program in maintaining a higher level of crop yields.

Under the crop yield and price conditions of 1947, it would seem probable that gross income (as well as net income) would have been lower for both groups of farms if the acreages of corn had been much smaller and hay acreage had been as much higher as is recommended for adequate conservation of soil. This, no doubt, is one of the major reasons for the tendency of many soil conserving farmers to raise larger acreages of corn, tobacco, or soybeans and less hay or rotation pasture than usually is recommended.

The soil conservation program on the nine farms would have been "more profitable" in the pre-war period than in 1947. The disadvantage for soil conservation would be even greater after the drop

in milk prices in October 1948. These facts illustrate the importance of thorough dollars and cents evaluation of alternatives in soil conservation plans for every farm.

La Crosse, Wisconsin, Orville E. Hays, Project Supervisor.

The year 1948 was outstanding for La Crosse in that no runoff occurred from most of the experiments during the growing season. Some plots yielded a small amount of runoff. This lack of runoff freed personnel so that new experiments could be planned and established.

New Experiments.

Grassland: This experiment is designed to give information on a grass-land rotation of grain and five years of hay in comparison with corn, grain, and four years of hay. There is considerable interest in the possibility of keeping much of this steep land in hay most of the time. There are several problems that need to be solved, however, before such a program can be adopted. First, how effective is such a rotation from a soil conservation standpoint? Second, will feed production be increased or decreased by not having corn in the rotation? Third, can the life of the legume be greatly extended by the use of annual applications of fertilizer?

Rotation Experiment: The backbone of most conservation practices is the use of a good crop rotation. This experiment is designed to evaluate the control to be obtained by six basic rotations. The rotations are: (1) corn, spring grain, hay; (2) corn, spring grain, hay, hay; (3) corn, spring grain, hay, hay, hay; (4) corn, spring grain, hay, hay, hay, hay; (5) spring grain, spring grain, hay, hay; and (6) winter wheat, spring grain, hay, hay. This study is located on the Miami silt loam near Madison.

Soil Types: There are now three soil types under measurement in Wisconsin - the Fayette at La Crosse, the Almema at Owen, and the Miami at Madison. On each of these soils there will be plots cropped to a four-year rotation of corn, spring grain, and two years of hay. A study of the data from this rotation should give information on the effect of soil type on soil and water losses. These soils are three very important ones in the State of Wisconsin.

Plum Valley Experiment: A group of farmers in Sauk County, Wisconsin, requested that an experiment be designed from which they could obtain information on soil losses under their conditions. Earth pits were used for catchment tanks with pipes to show the depth of soil deposited in the pits. Plot treatments include continuous corn, continuous hay, a rotation of corn, spring grain, and two years of hay, and two plots strip cropped in the above four-year rotation. All of the work on these

plots is done by farmers in the Plum Valley group. Although this is a crude type of experiment, it does give the farmer a chance to observe what is happening in his own back yard.

Results of Experiments.

1. A Study of the Effect of Crop and Rotation on Conservation of Soil and Water from Moderately and Severely Eroded Fayette Silt Loam.

Severely and moderately eroded Fayette silt loam soils have been under measurement since 1939. The severely eroded soils have three inches of surface soil and the moderately eroded soils have six inches remaining. The object of this study was to determine the effect of degree of erosion on soil and water losses and to determine whether a severely eroded soil could be increased in productivity. The results obtained to date on this study are reported in the December, 1948, issue of the Journal of the American Society of Agronomy in an article entitled, "Increasing Production on an Eroded Loess-Derived Soil."

A large part of the year's soil loss in 1948 came during late winter and early spring thaws. Soil losses from plowed corn land have been particularly high during these thaw periods. Studies need to be made to develop methods of reducing losses during these periods. Cover crops may be the answer. Spring plowing for corn will help and should be adopted where corn follows hay.

In 1948, yields of corn and hay were higher on the severely than on the moderately eroded soil. Yield of grain, however, was 45 bushels per acre less on the severe than on the moderate erosion. Plot treatments have included a five-year rotation with three years of alfalfa-brome hay, the liberal application of commercial fertilizers, addition of organic matter in barnyard manure and crop residue, and the use of conservation practices. Hay yields have not been materially affected by degree of erosion. Yield of corn has been increased on the severely eroded soil until it equals that produced on the moderately eroded soil. However, this improvement in productivity has not carried over into the grain year. There has been a consistent reduction in yield of grain as a result of erosion.

Nitrogen applied to severely eroded Fayette silt loam will greatly increase yields of corn and grain. Some burning was observed in 1948 on corn with the higher nitrogen treatments.

The Fayette silt loam is quite uniform in surface and subsoil except for organic matter and nitrogen content. It is a soil that responds very well to good treatment.

2. Conservation Efficiency of a Common Rotation on Different Slopes.

Runoff plots are located on slopes of 3, 8, 13, and 18 percent. During the period 1939 to 1943, inclusive, the plots were planted to grain. Flowing and planting were done up and down the slope. When grain is planted with the slope, the surface is quite smooth so that surface storage is small. Under these conditions the amount of runoff, especially during intense storms, did not vary with slope. Since 1943, the plots have been planted to a three-year rotation with all crops planted on the contour. Under these conditions, the amount of runoff increases as percent of slope is increased. This is because the capacity of the contour furrow decreases with an increase in percent of slope.

Soil loss under both treatments was directly influenced by an increase in the percent of slope.

3. The Effect of Organic Matter Treatments on the Erodibility and Permeability of an Eroded Soil.

Six different organic matter treatments were applied to a severely eroded soil to determine which treatments are most effective in reducing soil and water losses and in increasing crop yields. The treatments include: barnyard manure surface applied, barnyard manure plowed under, green manure surface applied, green manure plowed under, green manure plowed under plus barnyard manure surface applied, and no manure treatment. The green manure consisted of that crop produced after the first crop of second year hay had been removed.

Green manure left on the surface by means of sub-surface tillage was the most effective treatment in reducing soil and water losses. Yield, however, was reduced by this treatment. This reduction was due chiefly to the large amount of grass that was not killed and therefore was competing with corn for moisture and plant nutrients.

Barnyard manure applied at the rate of eight tons per acre has increased yields more than the green manure treatments.

4. The Effect of Renovation and Management of Bluegrass Pastures on Runoff and Soil Loss.

Soil and water losses are less during the renovation year from a pasture worked with a field cultivator than from an established pasture or from a plowed pasture. Soil loss from pastures renovated by the field cultivator has averaged 0.03 ton per acre as compared with 4 tons per acre from pasture that was plowed in seed bed preparation and 0.1 ton from bluegrass pasture.

Very satisfactory stands of legumes and grass can normally be established either by use of field cultivators or by plowing for seed bed preparation. The main problem seems to be to keep the stand of legumes. Stand counts show that in most cases the stand of legumes was reduced 50 percent by one year of grazing. After the first year's grazing the reduction in legume stand was, for the most part, rather gradual. Experiments are being planned to determine treatments necessary to maintain adequate stands of legumes in pastures for longer periods of time.

5. Strip Cropping and Factors Affecting the Practice as a Method of Conserving Soil and Water.

Strip cropping on an 11-percent slope has allowed an average annual soil loss of two tons per acre. This is about 60 percent as much as from contouring. The plots are 250 feet long and are planted to a rotation of corn, spring grain, and two years of hay. Strip cropping as a control practice depends upon the ability of the hay strip to sufficiently reduce the velocity of runoff water so that most of the soil washing from corn or grain will be deposited in the hay.

This experiment is designed in such a way that in a block of five plots there is one plot that measures soil and water losses from the four upper strips only. Three other strip cropped plots measure the soil lost from the five strips. Deducting the soil loss measured on four strips from that measured on five strips gives one a measure of the amount of soil eroded from or deposited on the fifth strips. The fifth strip loss on a 50-foot width of corn strip was 21.65 tons per acre, grain 1 ton per acre, and hay had a deposition of 7.43 tons per acre. These data would indicate that the soil movement within strips may be very high even though the total soil loss from the field may be relatively low. The fifth plot in each block is a 250-foot contour-
ed plot, the entire plot being planted to one crop.

6. Terraces with Different Vertical Spacing on Cultivated Land.

Two terraces are under measurement at the Station. This study of vertical interval was started in 1946. Vertical intervals of 7 and 12 feet are under measurement. Since the 12-foot vertical interval terrace was placed under measurement there has been insufficient runoff to indicate any trends.

7. A Study of the Effect of Terrace Spacing, Terrace Grades, and Terrace Cross-Sections on Surface Drainage, Crop Yields, and Soil Movement into the Terrace Channels.

During the year terrace studies were started on nine farms in the poorly drained Spencer soil area of north-central Wisconsin. The objective of this experiment is to determine the effect of terrace systems on surface drainage and crop yields.

Grain yields were determined on five farms. In all cases there was a slight increase in yield of grain on the terraced fields. In this study, channel type terraces are used. Measurements will be continued to determine the effect of these terraces on surface drainage and crop yields.

8. The Effect of Row Direction and Terraces on Soil and Water Losses from the Almena Silt Loam.

During the fall of 1947 measuring equipment was installed on additional plots at Owen on the Almena silt loam. During 1948 soil and water loss data were obtained from (1) four plots planted up and down hill to a 4-year rotation of corn, spring grain, hay, hay, (2) four plots contour strip cropped to a 4-year rotation of corn, spring grain, hay, hay, and (3) three plots planted up and down hill to a 3-year rotation of winter wheat, hay, hay. Four terraces planted to a rotation of corn, spring grain, hay, hay, were also under measurement.

Due to the low amount and low intensity of rainfall during the year, soil and water losses were low also. However, it is of interest that the soil loss from corn and grain planted up and down hill was 0.56 and 0.31 tons per acre respectively, whereas the losses from corn and grain on strip cropped plots were 0.02 and 0 respectively.

Laramie, Wyoming. O. K. Barnes, Project Supervisor.

Grasses and Legumes for Conservation Use in Wyoming.

Intermediate wheatgrass made a good showing at the Laramie Station in a new dryland pasture study. In this study, duplicate five-acre pastures were seeded in 1947 to (1) intermediate wheatgrass, (2) crested wheat and (3) crested wheat and alfalfa. These pastures were stocked with sheep for the first time in 1948. All pastures this first year carried the same number of animals and for the same period. It was noted during the grazing season that the sheep showed a high preference for intermediate wheatgrass. This was an observation made on the basis of comparing utilization of patches of volunteer crested wheatgrass within the intermediate wheatgrass pastures. It has also been noted that the intermediate wheatgrass becomes established rapidly in the area.

At the Archer Station, the dryland pastures are now going into their ninth year since seeding. Good ground cover has been maintained by all species throughout this period. The western wheat, blue grama and buffalo grass provides better cover than the cool season bunch grasses, although under our conditions the bunch grass maintain adequate cover on the drilled pastures.

At Archer the crested wheat with alfalfa continues to be the best pasture we have from a grazing standpoint. Russian wildrye is proving to be an excellent grass for summer-fall and winter use. The fall and winter use has not been under experimental conditions but observations clearly indicate high palatability. Chemical analyses show it to be relatively high in protein, calcium and phosphorous during the winter.

The dry season of 1948 reduced the grazing capacity of these seeded pastures to a point near that of native range. However, the 7-year average, including 1948, shows that the seeded pastures have supported from 2 to 2.8 times as much grazing as did the native range during the same period.

The results from this study strongly encourage greater use of grasses in this area and the combination of species along with legumes to fit seasonal needs.

Mechanical Treatments.

From studies on the Station, field trials and the field experience in eastern Wyoming, it appears that pitting can be recommended as a dependable conservation-improvement practice for shortgrass range land.

Pitting on a sagebrush-wheatgrass range type needs further study. In some situations pitting on this type appears beneficial and in others little benefit has developed since pitting two years ago. Further studies should be made on this type.

Pitting and seeding as a method of establishing other grasses in the native cover has been successful only to a limited extent. On a few sagebrush-wheatgrass types, crested wheatgrass has been successfully established by pitting and seeding. On the shortgrass plains, seeding of several cool season grass species in conjunction with pitting has largely failed.

The experimental pastures in 1948 again show a marked advantage for pitting. The pitted and grooved pastures carried 30 to 40 percent more sheep with more grass left at the end of the season as compared to non-treated pastures.

It appears that the life of the pitting treatment is longer than was anticipated. In this tenth year for one group of pastures, the pitting effects are still quite evident in the composition of the cover and grazing capacity.

Proper Range Utilization for Soil and Moisture Conservation.

The rate of forage removal study with sheep has now gone through five years. This is still early in its life to draw definite conclusions from the results. However, the trends shown by the data collected so

far indicate that with sheep this range type is more resistant to grazing than where cattle are used.

The results to date indicate the following:

1. Average utilization of the shortgrass species to .80 inch leaf height and 2.5 to 3 inches on western wheat apparently has shown no marked effects on the vegetation and production as compared to very light use which leaves 1.05 inches on the shortgrass and 4 to 5 inches on western wheatgrass. Only slight changes have developed so far under use leaving only .59 inch on the shortgrass and 1.5 to 2 inches on western wheatgrass.
2. Sheep gains have varied little between the three rates of utilization.
3. Some preliminary studies of root development indicate a deterioration under the heaviest rate of use.

The intensive rotation grazing study on a strictly shortgrass type showed little difference during this dry year as compared to continuous, season-long use. The stocking rate during 1948 was heavier on the rotation pastures but the degree of utilization likewise was heavier than on the continuously used check pasture. During the preceding three years, sufficient moisture was available to allow regrowth on the shortgrass and the rotation pastures carried approximately 25 percent more than the continuously grazed pasture.

SUMMARY OF ANNUAL REPORTS FOR CALENDAR YEAR 1948

R-2, DRAINAGE AND WATER CONTROL DIVISION

Auburn, Alabama, D. A. Parsons, former Project Supervisor.

R-2-3-1. Measurement of the Potential Erosivity of Natural Rains.

During the latter part of 1942 one of the recording rain gages used in connection with plot studies was equipped with 6-hour gears in order to obtain better determinations of rainfall rates. Recently the records for this gage for the four year period, 1943 through 1946, were analyzed for rain intensity. The 223 inches of rainfall that came during the period was divided according to months, and determinations made of the amounts and proportions that came at the several rates.

As has often been reported at other southern locations, the rates of summer rainfall were considerably greater than those for the winter months. For example, in January half of the volume of rain fell at a rate exceeding 0.3 inch per hour, and half at a rate less than this. In July the rate exceeded by half the volume was 1.3 inches per hour, which is more than four times the corresponding January rate. The rate exceeded by ten percent of the volume was 1.5 inches per hour in January and 3.3 inches per hour in July, the ratio of July to January rates in this case being only a little more than two.

The principal purpose of this study was to derive the intrinsic quality, namely drop-size distribution, of rainfall at this location as it varies throughout the year; and, by utilization of the results of other experiments, translate these determinations into a measure of the potential erosivity of the rain. In brief, the erosion data from small plot experiments with varying runoff rates and several levels of rain erosivity were analyzed to segregate the contributions to erosion of runoff water and rainfall impact. The resulting influence attributable to raindrop impact was utilized in the selection of a directly proportional function of raindrop size and speed. A series of graphs have been prepared expressing these ratios on a numerical basis. Compared to the erosive action of the Type F rainfall simulator, it was found less than five percent of the December rainfall was more erosive, while twenty percent of the January rains and seventy-five percent of the July rains were more intense.

R-2-3-1. Overland Flow Studies.

As the factors affecting the surface flow of water in the field are highly variable, the study was started in the laboratory under controlled conditions, first using various flow rates, over a wide range of slopes on a smooth, hard bed. This was compared with the depths of

flow over a rough permanent bed for various slopes and discharge. Following this, the increase in flow depth due to the impact of rainfall was determined.

The work was then carried to the field, using artificial rainfall of two different rates on small plots of bare ground of different lengths. Tests using artificial rainfall were then made on bare soil and on vegetation placed upon the 50-foot tilting plots, using two rainfall rates and varied slopes. Additional artificial rainfall tests on a few other vegetative covers were made in the field.

It was concluded that the true length of overland flow in the field was not the total length of the plot but extended from the plot boundary or the divide between rills, to the rill or concentrated flow down the slope. The flows in the rills were much deeper than elsewhere, but the proportional part of the area was not large. Measurements of the depth of flow through vegetation were made on annual Lespedeza, Lespedeza sericea, broom sedge and bluegrass. Good covers of bluegrass or annual lespedeza gave about four times the depth of flow to that occurring on uniform bare soil. The ratio of depths between good cover and bare rilled surfaces would be much greater.

E. H. Kidder, Project Supervisor.

Working plans have been developed for conducting new work on the erosion plots, the tilting plots, and the level plots. This study area has been enclosed by a chain link fence that was erected by the Alabama Agricultural Experiment Station. The Soil Conservation Service reseeded parts of the area to rye grass, cut and removed the vegetative growth, and cleaned up the area.

Rain simulator tests were conducted on the Norfolk and Decatur soils on the tilting plots by project personnel under the direction of Messrs. C. S. Britt and T. L. Copley. Our personnel changed the soil, set up the rain simulator, prepared the soil surface and incorporated the one- and two-ton per acre applications of oat straw. They operated the equipment during the test runs and collected the runoff and soil-loss samples. Artificial rainfall was applied at an approximate rate of 3.5 inches per hour. The runoff plots were 3.5 feet wide and 50 feet long.

The soil and water losses were collected to measure the effects of antecedent moisture, slope, flat vs. ridged surface, variations in the shape of the ridge, and the incorporation of 1 and 2 tons per acre of oat straw on erosion. Messrs. Copley and Britt will furnish a copy of their report when it is completed.

Lake Alfred, Florida, Citrus Experiment Station, James Turnbull,
Project Supervisor.

This project, which is cooperative between the Soil Conservation Service and the Citrus Experiment Station, continued and expanded the work reported on last year. Two new sets of irrigation plots were established, one on the Experiment Station property at Lake Alfred and the other on the County Farm at Fort Pierce. Runoff studies were established on the Indian River Farms Drainage District at Vero Beach.

The irrigation plots on the Experiment Station property were laid out to supplement those already established at Haines City. These new plots will enable us to obtain data on the effect of irrigation on Hamlin, Pineapple, and Valencia oranges and on Duncan and Marsh grapefruit.

The new plots on the County Farm at Fort Pierce were established to determine the relative efficiencies of various methods of irrigation on different soil types.

On the Indian River Farms Drainage District water level recorders have been set on the three main canals draining the district. A record of rainfall and runoff will be maintained on this district.

The experimental plots at Haines City were continued. On these plots we are applying different quantities of irrigation water in order to determine the optimum quantity of water per application.

But, though our experimental areas have been expanded, the objectives of our work have remained the same. Our efforts continue to be directed towards:

- I. Developing more efficient irrigation methods.
- II. Determining the effect of different quantities of irrigation water on the quantity and quality of fruit produced.
- III. Developing methods of destroying the extremely high resistance to wetting which occurs under citrus trees.
- IV. Determining the effect of variations in surface water level on ground water table.

Data have been obtained which indicate that under some conditions irrigation will increase the yield of fruit, will increase the size of fruit, and will increase the percentage of juice which the fruit contains. However, the data show that the quality of the juice obtained from irrigated fruit is somewhat lower than that obtained from unirrigated fruit.

Winter irrigation may result in lowered yields if the trees are damaged by frost subsequent to irrigation.

Data have also been collected which indicate that a mechanical hoeing device developed at this Station will significantly decrease the percentage of "difficult to wet" soil if used during the summer rainy season. Water table wells on the Dr. Sample grove were found to vary independently of lake level except when the lake was very high. At these higher levels the lake affects the water table as far as 150 feet back from the lake.

Homestead, Florida, M. H. Gallatin, Project Supervisor.

Project D-1-2-4-(Irrigation Studies on the Rockdale Soils of the Homestead Area).

Water Table Studies.

Our records of water table readings show that especially during the winter months the ground water slopes from the Everglades to the Coast. During excessive high water there is a flow in both directions toward the Everglades and toward the Coast. There is a wide variation in rainfall as recorded by gages throughout the area.

Records indicate quite definitely that the water table in the Rockdale area is recharged from the Everglades, and that the chloride barriers in the Coastal Canals are helping to hold back the outflow of fresh water.

Water Table as Affected by Rainfall.

This study shows that virgin surface soil will absorb approximately .5 inch of rain. The amount of water scarified and planted soils will retain is dependent upon type of material, depth of scarification, shade conditions and amount of organic matter present. One inch of rainfall will raise our water table approximately 3 - 3-1/2 inches.

Leaching of Plant Nutrients.

This study shows that nitrogen fertilizers which have a low percentage of natural organics leach badly. Cyanamide holds a good constant level of nitrogen and will not leach readily.

Moisture Studies (Mulch Plots).

This study shows that while shavings actually conserve more moisture than grass or pine straw, it has a tendency to shed moisture. To date this study shows that the materials used assume the following order so far as conserving moisture goes: Shavings, pine straw, grass,

natural cover, and check plot. This study shows that any good mulching material will conserve moisture. Samples taken periodically from the plots and analyzed for nitrates show that the shavings, check and natural cover plots run low in nitrogen, whereas the pine straw and grass at times have as much as 30 - 50 P.P.M. of nitrate nitrogen.

Moisture Irrigation Studies.

During the winter months the irrigation cycle must be shortened to maintain adequate moisture. Percentage of organic matter, depth of material, maturity and shade conditions of the grove are important in determining the length of the cycle.

Project D-1-2-5 - (Intrusion of Chlorides into the Marl Lands of the Homestead Area).

Chloride barriers placed in the canals of the Miami and Homestead areas are effective in reducing chloride intrusion. Our study has shown that while the barriers are effective there is an outside disrupting factor on the Military, North and Florida City Canals, for the past two years there has been a definite rise in the concentration one mile back from the barriers.

To be completely effective all of the canals in the area must be controlled.

Water Control, Highlands.

It is possible in the marl lands to control the water within a given area by use of the marl seal type of ditch. By controlling the water we were able to plow our water control plot 10 days to three weeks earlier than surrounding areas.

Bedding of an area proved beneficial in aiding faster removal of surface water, and this was plowed 10 days earlier than the unbedded areas.

Athens, Georgia, John R. Carreker, Project Supervisor.

Hydrologic Studies.

A total 1948 rainfall of 65.47 inches exceeded the long-time average of 49.95 inches at Athens, Georgia, by 15.52 inches. Six drought periods occurred during the growing season, however, ranging in length from 16 to 27 days.

Irrigation water was applied to the vegetables, corn, and pastures with rotating sprinklers mounted above light-weight portable pipe.

Water was applied to one series of vegetable plots by gravity flow in furrows between rows. All crops had equal areas of unirrigated plots for checks.

Soil moisture records indicated little need for irrigation except during the first week of July, in late September and late October.

Pasture Irrigation.

Four acres of permanent pasture were divided as in 1947 into four 1-acre plots, two of which were irrigated and two unirrigated. They were stocked to their relative carrying capacities from April 15 to October 26 with 2-year-old Jersey and Guernsey heifers. Five irrigations of 2 inches and three of 1 inch were applied. Results were as follows:

| | Unirrigated | Irrigated | Increase | | | | |
|----------------------------------|--------------|--------------|----------|------|------|------|------|
| Animal-grazing days* | | | Per cent | | | | |
| per acre | 225 | 301 | 34 | | | | |
| Weight gain, pounds | | | | | | | |
| per acre | 340 | 447 | 32 | | | | |
| | Unirrigated | Irrigated | Increase | | | | |
| | Pasture Avg. | Pasture Avg. | Per cent | | | | |
| | III | IV | I | II | | | |
| Pasture herbage produced, tons/A | 1.65 | 2.39** | 2.02 | 2.55 | 2.71 | 2.63 | 25.5 |

A test was begun in the winter of 1947-8 on use of irrigation to establish and maintain pasture for winter grazing during the normally dry fall seasons. The second irrigation was interrupted by rain in mid-October 1947. No further irrigations were needed. Three animals were kept on each two-acre irrigated and unirrigated pasture. From December 12, 1947 to April 15, 1948 each acre of both pastures afforded 181 animal-grazing days. Weight gains during this time were 214 pounds per acre on the irrigated and 274 pounds per acre on the unirrigated area respectively.

Corn Irrigation.

Two irrigation practices were tested on the corn plots in 1948. One consisted of applying irrigation water whenever needed throughout the season, while in the other, applications of water were made in dry periods that occurred only after the fruit had begun to form. Both were checked with plots receiving no irrigation.

* Not corrected to 1000-pound cow units.

** Excessive growth of bull nettle unduly increased records in pasture IV.

An irrigation was made on all plots, including the check areas, prior to planting to insure germination. Two 1-inch irrigations were made prior to tasseling and two 2-inch irrigations were made during the fruiting stages on appropriate plots. The latter two irrigations were followed by heavy rains within three days.

Three fertilizer and two plant population variables were included in these tests. Results (not corrected for stand) are given in the following tabulation:

Average yield of corn plots in 1948:

| | Fertilizer & population rates* | | | |
|---------------------------------|--------------------------------|------|------|------|
| | A | B | C | D |
| | Bushels per acre | | | |
| Irrigate all season | 69.8 | 70.4 | 84.3 | 81.7 |
| Irrigate at fruiting stage only | 60.8 | 66.3 | 73.3 | 69.1 |
| No irrigation | 57.1 | 68.1 | 73.7 | 74.8 |

According to an analysis of variance, the differences in yield due to irrigation in 1948 were not significant. The yields from the fertilizer rate C application were significantly more than those from rates A and B. The differences in yield due to the population differences C and D were not significant.

Vegetables Irrigation:

Tomatoes and lima beans were planted on the vegetable plots in 1948 after the entire plot area had been treated with a soil fumigant to control root knot nematodes.

Three irrigation practices versus no irrigation were studied. In two of the practices irrigation water was applied to supplement rainfall, giving the plants a minimum of 1 inch per week. Sprinklers were used to apply water in one of these practices; and in the second gravity flow along furrows distributed the water. In the third practice water was applied through sprinklers in an amount equal to evaporation losses from the evaporation pan (after deducting rainfall).

Six furrow irrigations and eight sprinkler irrigations were applied from May through August, the effective period of growth and harvest. In most cases rains followed immediately or within a few days after irrigation applications. No soil moisture deficiency occurred from mid-July to late August, which was the critical period for both crops.

Cooperative Studies at the Southern Piedmont Conservation Experiment Station.

Cooperative studies on alfalfa irrigation at the Southern Piedmont Conservation Experiment Station showed an increase of 28% in the cutting obtained after an irrigation on July 27. Two 2-inch irrigations on cotton resulted in a 57% increase in yield of seed cotton on Class III upland.

Surveys of field installations.

Two detailed surveys of field installation were made in 1948. One of these was the State Forestry Nursery near Sandersville, Georgia, where water from a deep well is supplied to 40 acres of pine seedlings through portable pipe and sprinklers. The other was made at the Dyar Bros. dairy farm in Greene County. The Dyars use a perforated pipe system to irrigate six acres of pasture.

Lafayette, Indiana, R. B. Hickok, Project Supervisor.

Runoff and Soil Loss Investigations—Lafayette, Indiana.

The objectives of this research are primarily to determine for conditions representative of much of the eastern part of the cornbelt: (1) the nature and magnitude of water and soil losses by surface runoff under present typical farming practices, and (2) how these losses may be affected by a conservation system of farming such as may become typical within a few years. Water losses by runoff and the erosion losses, including the losses of organic matter and fertilizing elements, are being measured from 20 small watersheds in rotation crops (4-yr. rotation of corn, soybeans, wheat and meadow), permanent pasture and wood-lot. The watersheds, in rotation crops, are divided into two similar groups, one group under a conservation system of management and the other under a system representative of common practices. Data being collected for each type of land-use, crop and management system are: (a) seasonal water and erosion losses (including losses of organic matter and available plant nutrients); (b) critical rates of runoff affecting the capacity design of runoff handling structures; and (c) the influence of soil conditions, character of rainfall, etc. on the runoff rates and amounts, and the erosion losses.

Data have been collected for 7 years and while effects of land-use and treatment on runoff and erosion are strongly indicated, the absolute values are shown to vary widely from year to year, depending largely on the occurrence of a few major storms which normally cause a large part of each year's losses. The number, character and dates of occurrence of these influential storms enter into the seasonal variability of the experimental data. Accurate estimates of long-time mean runoff and erosion losses, and of probable intensity-frequency relationships of runoff rates, according to the land-use,

type of management and the character of the land, will require several additional years' experimental data.

The utility of such estimates for appraisal of future crop production potential and the design of erosion control, moisture conservation and flood control measures, and the possibilities of their determination from the experimental data being collected, with long-time weather records available, have been demonstrated in a paper "Runoff Control and Moisture Conservation Possibilities" by Hickok, Mayer and Kohnke, published in the June, 1948 issue of Agricultural Engineering (Journal of American Society of Agricultural Engineers, St. Joseph, Michigan).

Mulch Tillage and Crop Residue Management Studies.

Conservation practices based on contour operations are not feasible in some morainic areas of Northern Indiana and nearby States, where surface configuration is complex or "hummocky," with very short, irregular slopes. In other localities contour tillage is not entirely effective, early in the crop-season, before contour ridges and furrows are fully developed. To meet these needs, research is under way to develop practical methods of utilizing crop residues for mulches to protect the soil surface from erosion, increase infiltration of rainfall and reduce moisture losses by evaporation. The problem involves mechanical difficulties in development of the mulch, seedbed preparation, and in seeding and cultivation under the mulch. It also involves slower drying and cooler soils in the spring and disturbance of chemical and biological processes in the soil, affecting nutrition and growth of crops and possibly disease and pest infections. Its main aspect in Indiana and nearby States is developing a satisfactory mulch culture for corn, utilizing meadow residues. The research carried out under this project includes: (1) study of several experimental tillage treatments for corn and their residual effects in the ensuing seasons of the crop rotation, with respect to soil and moisture losses and crop yields, and (2) study of equipment and operational methods for accomplishing these tillage practices.

The experiment is conducted at two locations in the State. The central part of the State of Indiana is represented by the Purdue-Throckmorton Farm near Lafayette, Indiana; this farm represents an area of relatively fertile, slowly draining prairie soil. The northern part of the State is represented by the Noble County Farm near Albion, Indiana, and Harmon Harper Farm, Cromwell, Indiana. This represents an area of moderately fertile light soil. The slopes are steep and badly broken and erosion is serious on large acreages of this type land.

The yield of crops other than corn is about the same no matter how the soil is prepared for corn. The largest differences in yield are for corn. Corn on the Purdue-Throckmorton Farm gave increased yield from the conventional plow - 141 bu. per acre, while the mulch system yielded more than 100 bu. of corn per acre. This was a reduction of about

25% from the conventional plow. However, corn responded to mulch treatment on the light sandy soils in Northern Indiana and the yields there were similar for both mulched and plowed corn plots.

Some improvements in techniques are planned for 1949 crops especially corn. There will be an increase in the quantity of fertilizer used; this will increase the available nutrients to growing corn. One plot has been changed to a fall treated plot to determine if the time of decomposition can be changed so that it will not coincide with the maximum growing period of corn.

Walkerton, Indiana, R. B. Hickok, Acting Project Supervisor.

Water Control Investigations in Muck Soils—Walkerton, Indiana.

The ground water table is maintained at various depths in experimental plots on muck soil during the cropping season to determine its effect on the rates of oxidation of the muck and resulting loss of depth and subsidence of its surface elevation, and on the production of various specialty crops commonly grown on muck.

A major part of the work during the past year has been improvement of the physical set-up of the experiment. Old wooden structures for control of water levels were replaced by more permanent steel structures. Spacing of tile lines was reduced from 50 to 25 ft. for better control, and greater uniformity of depths to the ground water within the individual plots, and the number of observation wells was increased from 5 to 11 per plot for better sampling of depths.

Floods of backwater from the Kankakee River have affected the results of several previous years of the experiment. Consequently, to continue the work it was necessary to raise and extend a protective levee around the experiment farm, provide a system of automatic check gates in outlets from the area and improve the provision for pumping out surface water.

Spring floods and necessary construction work delayed bringing the water levels under control the past spring. This and poor growth of crops on the plots rendered the current year's data on crop response to the experimental treatments of little value.

Subsidence measurements were made in the fall on the experimental plots and on two private muck tracts. A summary of the 5 years' data from the experimental plots indicated mean annual rates of subsidence ranging from 0.04 to 0.10 ft. per year, and indicated a positive linear correlation to the depth to ground water during the cropping periods. (Water levels were maintained uniformly high during off-crop periods.)

Baton Rouge, Louisiana, I. L. Saveson, Project Supervisor.

This year's work consisted of the following:

1. Studies on areas previously crowned to determine the effect of the amount of crown and the precision of crowning on yields of sugar cane. Experimental tests of the efficiency of crowning cuts of sugar cane land were previously carried out on a heavy blackland soil at Smithfield and on a tract near Westover where the soil ranged from sandy to some heavier soil types.

The harvesting data at Smithfield showed an increased yield of cane with a more rapid increase in sugar content as the crown of the cut was increased up to a maximum of 13 inches per 100 feet. Where the crown was increased beyond this point the yield of both cane and sucrose in the cane decreased. In making cuts on this heavy soil it was found to be essential to avoid doing any grading where the land was exceptionally wet.

On the Westover area the stand of cane on the graded land was variable, due apparently to pondage caused by variations in the accuracy of grading. It was concluded that pondage should not exceed 10 percent in field practice and for the best yields should be less than 1 percent.

2. Test areas have been set up to study the possibility of widening ditch spacing in conjunction with cut crowning. Test areas were also laid out to study the effect of flat planting on the drainage of sugar cane land. In addition studies were installed to find the maximum width of ditch spacing that can be used on land of mixed textures without crowning.
3. Field trials were run with encouraging results, using the mole drainer developed by the project.
4. A topographic survey was made of a tract of 260 acres which is to be used for additional experimental work.
5. Preliminary trials were carried out on the following items of new equipment:
 - a. A 4 cubic yard scraper for cut crowning.
 - b. A small land leveler to use in conjunction with cut crowning.
 - c. A Chattin ditcher to be adapted to Louisiana conditions for ditch cleaning.

College Park, Maryland, Harold W. Hobbs, Project Supervisor.

A summary of precipitation and runoff data on 6 of the 10 watersheds under study at the Plant Research Farm was possible at the end of October 1948. At that time, 9.2 to 8.2 years of record were available for 3 major experimental periods: 1939-42 (initial period), 1942-45 (second period) and 1945-48 (third period). The effect of change in land use practices were determined for:

1. Strip cropping vs. up and down the slope tillage in corn, wheat & hay rotation;
 - a. W-II, 7.44 acres, 72% well-drained soils, 34 inches average depth. (Fig. 1)
 - b. W-I, 8.22 acres, 90% imperfectly or poorly drained, 27 inches average depth.
2. Regular pasture vs. contour pasture furrows on W-VII, 3.53 acres, 84% imperfectly or poorly drained, 18-inch average depth. (Fig. 2)
3. Mature woodland vs. logged area, 12.05 acres, 78% well-drained, 22 inches average depth. (Fig. 2)

The 9-year monthly averages at the farm showed an excess in the precipitation, in comparison with the 60-year College Park record, for May, 6.6%; July, 9%; August, 4.7%; October, 12.4%; and for November, 27.4%. The other 7 months were less by percentages varying from 1.4 to 24.4, however the annual average at the farm was only 0.65% greater than the long record. Snow and sleet comprised 13.2% of the average precipitation.

Seasonal averages are shown in Table 1, in comparison with the long-term and concurrent seasons at College Park. The summer and winter averages at the farm for the initial (1939-42) period were lower than the 60-year averages and the concurrent record at College Park, therefore the runoffs may have been somewhat below average expectancies. In the second and third periods, the summers were considerably greater than the long-term record, while the second was about the same and the third considerably below the concurrent College Park record. Runoffs in the second and third periods during summers may be above long-term expectancies, but could have been higher if the third period rainfall at College Park had happened to fall at the farm, which is only 5 miles away. Winter averages were somewhat more than the corresponding concurrent averages at College Park, but either were about the same or a little lower than the long period. Therefore, winter runoffs in the second and third periods may have been a little lower than ordinary expectancies.

Rainfall intensities for 10- to 30-minute durations influence greatly the peak rates and total runoffs from watersheds of 2 to 12 acres. Table 2 shows the frequencies for 2- and 10 years for the three periods

and total period in comparison with Yarnell's data based on 30 years of record. Ten-minute rainfall rates for 2- and 10-year frequencies are somewhat above Yarnell's values and the 30-minute rates about the same, so it seems likely that the runoffs in all the periods were above ordinary expectancies as far as rain intensities are concerned.

The number and distribution of excessive storms in the three periods were above Yarnell's numbers generally and for the 9-year period were above in 8 of the 12 months, averaging 9% greater on an annual basis. From the standpoint of number of excessive storms, the runoffs in all periods can be expected to be above average in number.

The results of the change in land use practice on average seasonal runoffs are shown graphically in Figures 1 and 2. The effects on peak rates of runoff are shown in Table 3 for 2- and 10-year frequencies.

In Table 4 are shown the rates of water and silt losses and total losses of each for two significant storms in July 1945 for strip cropping compared with up and down the slope tillage.

Table 1.--Average Seasonal Precipitation at Plant Research Farm Compared with Concurrent and 60-Year Record at College Park, Maryland

| Period | AVERAGE SEASONAL PRECIPITATION IN INCHES | | | |
|-------------------------------------------------------|------------------------------------------|------------|---------------------------|------------|
| | R-1 Plant Research Farm | | Campus, College Park, Md. | |
| | Winters | Summers | Winters | Summers |
| | (Nov.-Apr.) | (May-Oct.) | (Nov.-Apr.) | (May-Oct.) |
| 1939-42 | 16.82 | | 17.01 | |
| 1939-42 | | 21.99 | | 23.20 |
| 1942-45 | 19.03 | | 18.38 | |
| 1943-45 | | 24.25 | | 24.09 |
| 1945-48 | 18.40 | | 17.83 | |
| 1946-48 | | 24.99 | | 27.97 |
| 1939-48 Average | 18.09 | 23.62 | 17.74 | 24.96 |
| 1889-1948 60-Year Seasonal Average..... | | | 18.86 | 22.58 |
| 1898-1932 35-Year Weather Bureau "Normal" Season..... | | | 18.56 | 21.79 |

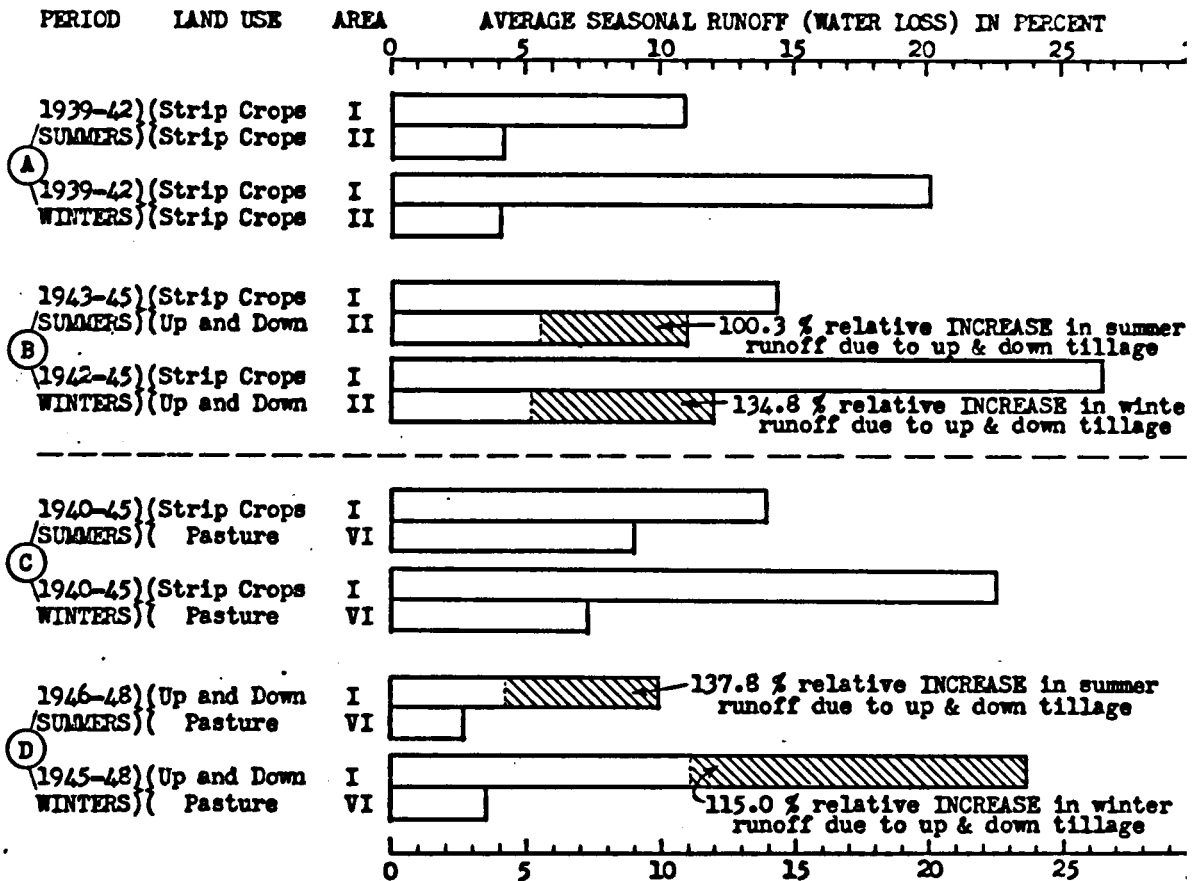


FIGURE 1.

ABOVE GRAPHS SHOWING THE INCREASE IN SUMMER AND WINTER RUNOFF THAT OCCURRED ON A WELL-DRAINED SOIL, AREA II, FOLLOWING A SHIFT FROM STRIP CROPPING TO UP AND DOWN THE SLOPE TILLAGE, IN A CORN, WHEAT AND HAY ROTATION:

- A.- Runoff for initial comparative period when both areas were strip cropped for 3.2 years.
- B.- Runoff from same watersheds after up and down tillage had been imposed on Area II for 3 years.

BELOW GRAPHS SHOWING THE INCREASE IN SUMMER AND WINTER RUNOFF THAT OCCURRED ON AN IMPERFECTLY DRAINED SOIL, AREA I, FOLLOWING A SHIFT FROM STRIP CROPPING TO UP AND DOWN THE SLOPE TILLAGE, IN A CORN, WHEAT AND HAY ROTATION:

- C.- Runoff for an initial comparative period of 5.2 years when Area I was strip cropped and Area VI was in regular permanent pasture.
- D.- Runoff from the same watersheds after up and down tillage had been practiced on Area I for 3 years.

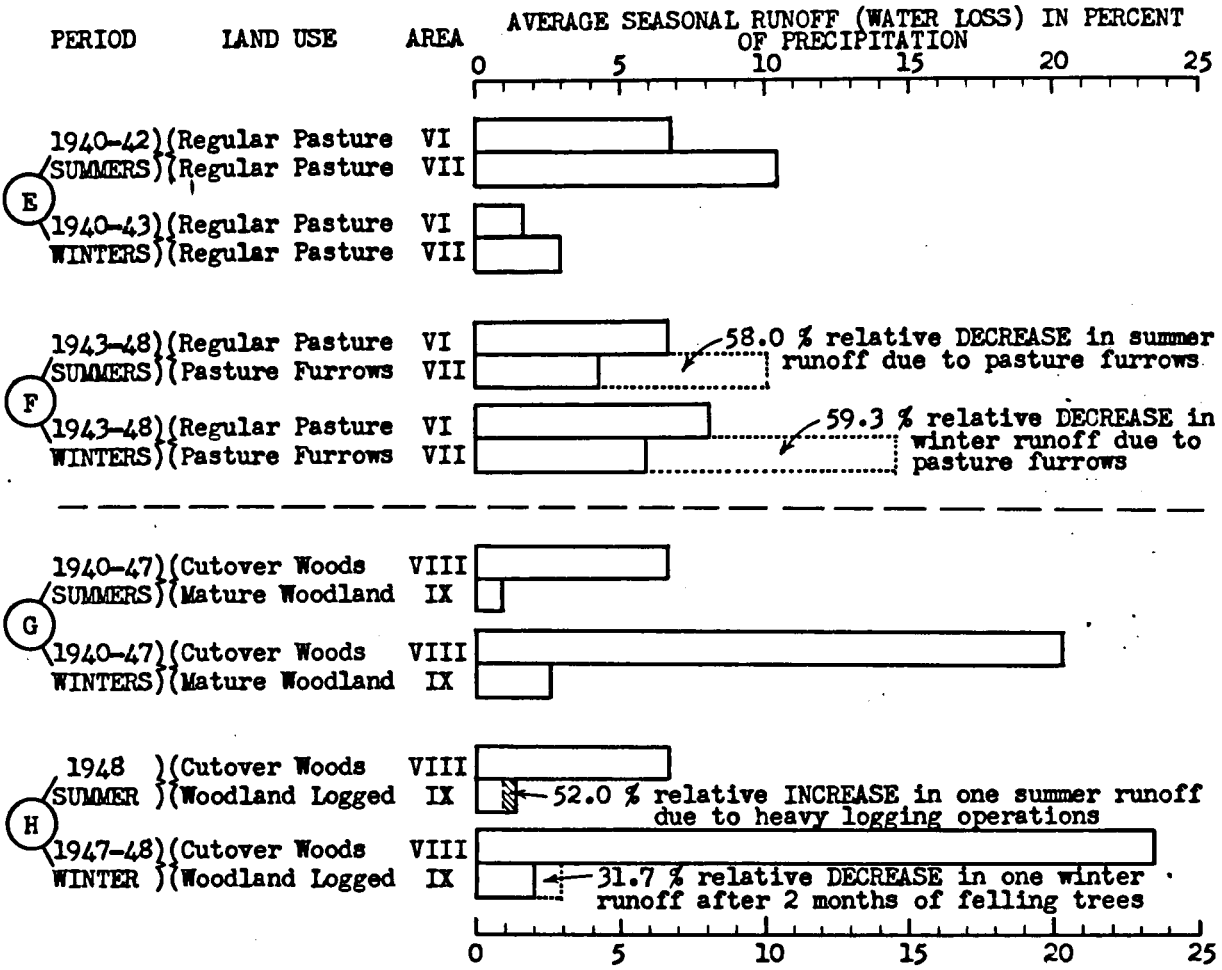


FIGURE 2.

ABOVE GRAPHS SHOWING THE DECREASE IN SUMMER AND WINTER RUNOFF THAT OCCURRED ON A SHALLOW, IMPERFECTLY DRAINED SOIL, AREA VII, FOLLOWING PLOWING IN OF CONTOUR PASTURE FURROWS WITH 20-FOOT SPACING ON STEEPEST SLOPE:

- E.- Runoff for an initial comparative period of 2.7 years when both areas were in regular pasture, heavily grazed.
- F.- Runoff from the same heavily grazed pastures after contour furrows had been operating on Area VII for 5.5 years.

BELOW

GRAPHS SHOWING THE INCREASE IN ONE SUMMER RUNOFF AND THE DECREASE IN ONE WINTER RUNOFF ON A MATURE WOODLAND ON A WELL-DRAINED SOIL, AREA IX, FOLLOWING A HEAVY CUTTING OF THE MIXED HARDWOOD AND PINE STAND:

- G.- Runoff for an initial comparative period when the forested Areas VIII and IX had not been disturbed for 7.5 years or more.
- H.- Runoff from same areas after heavy logging operations on Area IX had drastically reduced the canopy and disturbed the forest litter in many places.

Table 2.—Frequency of Rainfall Intensities that Occurred at Plant Research Farm for Various Periods Compared with Yarnell's Modified 30-Year Values

| Duration: Minutes | Frequency: Once in - | :Rainfall Intensities in Inches per Hour:Yarnell's 30-Year :at R-1 for Various Experimental Periods:Rates +10 to 5% 1/ :1939-42 : 1943-45 : 1946-48 : 1939-48 : Inches per Hour | | | | |
|-------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| 10 | 2 years | 4.80 | 5.10 | 4.90 | 5.05 | 4.68 |
| 10 | 10 years | 6.70 | 6.50 | 7.20 | 6.90 | 6.33 |
| 30 | 2 years | 2.40 | 2.70 | 2.45 | 2.47 | 2.57 |
| 30 | 10 years | 3.35 | 3.80 | 3.90 | 3.35 | 3.72 |
| 60 | 2 years | 1.35 | 1.45 | 1.22 | 1.35 | 1.50 |
| 60 | 10 years | 1.70 | 1.85 | 1.77 | 1.66 | 2.36 |

1/ Rainfall Intensity-Frequency Data by David L. Yarnell, USDA Misc. Pub. No. 204, 1935 (see page 5). Yarnell's data based on uniform 5-minute rainfall intensities as tabulated by Weather Bureau prior to 1935. Actual intensities for 10 minutes may be 10% greater; for 30 minutes, 7% greater; and for 60 minutes, 5% greater. R-1 intensities are the actual maximums.

Table 3.—Effect of Change in Land Use Practices on Peak Rates of Runoff (Design Capacities for Structures) on Cultivated and Pastured Lands

| Area | Land Use | Period | : Peak Rates of Runoff in : Base or % of Base | | :and Percentage Change | |
|--------------------------------------------------------------|-------------------|---------|---------------------------------------------------------------------|----------|-----------------------------------------|----------|
| | | | :Inches per Hour that will: :be Exceeded Once in 1/ : 2 years | 10 years | :in Peak Rates for Once in : 2 years | 10 years |
| W-I | Strip Cropping | 1939-42 | 1.14 | 3.40 | 100 | 100 |
| W-II | Strip Cropping | 1939-42 | .67 | 1.08 | 58.8 | 31.8 |
| W-I | Strip Cropping | 1943-45 | 2.55 | 4.12 | 100 | 100 |
| W-II | Up & Down Tillage | 1943-45 | 2.40 | 2.88 | 94.2 | 69.9 |
| INCREASE in peak rates on W-II due to up & down tillage..... | | | | | +60.3% | +119.5% |
| W-VI | Regular Pasture | 1940-45 | 1.88 | 3.05 | 100 | 100 |
| W-I | Strip Cropping | 1940-45 | 2.15 | 3.58 | 114.2 | 117.3 |
| W-VI | Regular Pasture | 1945-48 | .88 | 1.98 | 100 | 100 |
| W-I | Up & Down Tillage | 1945-48 | 1.72 | 3.90 | 195.3 | 197.0 |
| INCREASE in peak rates on W-I due to up & down tillage..... | | | | | +70.8% | +67.8% |
| W-VI | Regular Pasture | 1940-43 | 1.56 | 2.50 | 100 | 100 |
| W-VII | Regular Pasture | 1940-43 | 2.08 | 4.05 | 133 | 162 |
| W-VI | Regular Pasture | 1943-48 | 1.76 | 3.02 | 100 | 100 |
| W-VII | Pasture Furrows | 1943-48 | 1.47 | 2.20 | 83.4 | 72.8 |
| DECREASE in peak rates on W-VII due to pasture furrows..... | | | | | -37.4% | -55.1% |

1/ Frequency of peak rates of runoff determined by duration-curve method, using Hazen's modified log-probability plotting paper. See "Rates of Runoff in the Coastal Plains of New Jersey, Delaware and Maryland" by Harold W. Hobbs USDA SCS-TP-60, 1946, pages 25 to 27.

Table 4.--Rates of Water and Silt Losses and Total Losses for Two Significant Storms: Strip Cropping Compared with Up and Down Tillage

| Date of Storm | : W-I, 8.22 Ac. Strip Cropping | | | | | | : W-II, 7.44 Ac. Up & Down Tillage | | | | | | |
|------------------------------------------------|--------------------------------|---------------|--------------------|------------|-----------------|--------------------|------------------------------------|--------------------|---------------|-----------------|--------------------|---------------|--------------------|
| | :Total: | :Peak Rate | : | :Total | : | :Peak Rate | : | :Total | : | :Peak Rate | : | :Total | |
| 1945 | :Rain-:fall | :Water:in/hr. | :Silt:Loss:lb/c.f. | :Water:in. | :% of:Rain-fall | :Silt:Loss:lb/c.f. | :Water:in/hr. | :Silt:Loss:lb/c.f. | :Water:in. | :% of:Rain-fall | :Silt:Loss:lb/c.f. | :Water:in/hr. | :Silt:Loss:lb/c.f. |
| July 17 | 2.29 | 1.85 | .081 | 1.83 | 74.5 | .425 | 1.84 | .455 | 1.23 | 50.2 | 1.53 | 5.6 | 3.6 |
| INCREASE on W-II due to up & down tillage..... | | | | | | | times greater | | times greater | | | | |
| July 22 | 1.81 | 3.61 | .089 | 1.19 | 66.5 | .496 | 2.47 | .570 | 1.01 | 55.6 | 1.91 | 6.4 | 3.9 |
| INCREASE on W-II due to up & down tillage..... | | | | | | | times greater | | times greater | | | | |

1/ Based on assumption that all silt losses occurred on corn lands only, that is, that no losses occurred on wheat stubble or hay areas.

East Lansing, Michigan, George A. Crabb, Jr., Project Supervisor.

There were no unusual storms during the past year. Precipitation was relatively normal. Soil moisture studies on wooded and cropped watersheds have been continued so as to follow the movement of precipitation down through the profile to a depth of 60 inches. Work on solar radiation has also been continued as it has been felt that this data will be of value in showing the most favorable periods of tree and plant growth.

Stubble Mulch Experiments.

The field trials of stubble mulch culture have been carried on from 1942 through 1948. The methods of cultivation have compared four types of tillage. These are as follows:

1. Normal tillage in which the land was plowed for corn, oats and wheat. Supplementary treatment consisted of disking, harrowing with a spring-tooth harrow, and culti-packing.
2. Disk tillage in which the crop residues were mixed with the surface soil with a double tandem disk. Corn, wheat, and oats were again grown. Supplementary tillage consisted of packing with a treader.
3. Subsurface tillage or stubble mulch farming in which the land was prepared with sweeps. Supplemental preparation of the seedbed consisted of packing with a treader.

4. Plowing with the moldboard removed from the plow which partially mixed the crop residue and stubble with the surface soil. Supplementary preparation consisted of disking, harrowing, and culti-packing as in normal tillage.

In general it was concluded that the plow was the most satisfactory implement for preparing crop land under the conditions found in East Lansing. Two factors contributed to better production on the clean plowed land. Wheat grown on the stubble mulch plots, subsurface tilled, as well as that disked and plowed with the moldboard removed, showed definite signs of nitrogen deficiency. Weed control was more of a problem on stubble mulch than on clean plowed land. Oats grown on the stubble mulch in 1943 and wheat in 1948 were complete failures due to weed growth. Great difficulty was experienced in cultivating the corn in the stubble mulch plots the first time because of weeds.

Although the stubble mulch decreased erosion losses it was concluded that the larger yields obtained with plowing and the greater freedom from weeds made plowing the most desirable method of land preparation for general farming on soils adapted to normal rotation cropping in Michigan. It has therefore been recommended that the stubble mulch experiments should now be terminated.

Minneapolis, Minnesota, F. W. Blaisdell, Project Supervisor.

During the first nine months of the 1948 calendar year our efforts were concentrated on research which will have general application. In contrast, during the last three months of the calendar year our major efforts were concentrated on studies of the drainage system of the Whiting Naval Air Station near Milton, Florida. Studies actively prosecuted during the year and their status at the end of the year are as follows:

1. The SAF Stilling Basin.

The closing discussion of the paper entitled "Development and Hydraulic Design, St. Anthony Falls Stilling Basin" was prepared and the complete paper plus all of the discussions were published in the TRANSACTIONS of the American Society of Civil Engineers, Volume 113, 1948, pp. 483-561.

2. Outlet for Box Inlet Drop Spillways.

A report on the tests and complete rules for the design of an outlet for box inlet drop spillways was published during the year as SCS-TP-63 for the use of Soil Conservation Service technicians.

3. Open Channel Transitions at Supercritical Velocities.

A graduate student at the University of Minnesota made tests with the transition located on normal or friction hydraulic slopes and prepared a thesis based on these tests. Transitions can now be designed for normal slopes as well as for the flat slopes reported previously. Another graduate student is now studying the effect of channel roughness on flow through expanding transitions set on normal slopes and operated at supercritical velocities.

4. Box Inlet Drop Spillways.

An analysis of all available pertinent head-discharge data was made and a method developed by which the flow over this type of spillway can be computed for different box inlet shapes, different heads, and different approach channel widths, as long as the box is not flooded out. Insufficient data were available when the study was temporarily suspended to determine the head-discharge relationship when the box is flooded out.

5. Drop Inlet Spillway (Pipe Conduit).

A new test setup was completed and the data required to complete the preliminary test program were obtained. A report will be made before additional studies are undertaken. Only the outline for the report had been completed at the end of the year.

6. Flow Over Box Inlet Drop Spillways with High Tailwater Levels.

Good progress was made on this study until it became necessary to temporarily suspend work in October. About three months will be required to complete the planned test program when the study is resumed.

7. Whiting Naval Air Station, Milton, Florida.

After late September most of our time was spent on a study of drop structures, combination pipe outlet and ditch entrance structures, ditch junctions where the flow is at supercritical velocities, and ditch outlet structures. This direct assistance to Operations was necessary because of the very difficult problems encountered in the design of a new drainage system for the Whiting Naval Air Station at Milton, Florida. Tests on one model had been completed and three other models were being tested at the close of the year.

8. Stiles Hydroelectric Development.

The design of a stilling basin for the Stiles Hydroelectric Development of the Oconto Electric Cooperative, Oconto Falls, Wisconsin was reviewed in February at the request of the Rural

Electrification Administration. The design submitted by the consulting engineers was not felt to be adequate and the value of some features of the design was questioned. Model tests were recommended.

9. Training Conference.

A two-day training conference was held in November for the Soil Conservation engineers and engineering aids located in the State of Missouri. At this meeting the "how" and "why" of hydraulic research and the structure designs developed at the St. Anthony Falls Hydraulic Laboratory were stressed so that the field men could have a better understanding of the structures they are called on to design and build. As a result of this conference, requests were received for two additional training sessions to be held in the spring of 1949.

State College, Mississippi, Russell Woodburn, Project Supervisor.

During the past fiscal year a new project, "Investigation of Sedimentation Control in the Yazoo Basin in Mississippi," was started, working in close cooperation with the Agricultural Engineering Department of the Mississippi Agricultural Experiment Station.

The activities thus far may be briefly summarized as follows:

1. Considerable effort has been made in acquiring the best available maps of the Yazoo-Tallahatchie watershed.
2. Considerable time has been spent in the field in becoming familiar with the sedimentation problems of the area. These consist of (a) stream and valley sedimentation in the upper head water areas, (b) channel sanding and lateral cutting and meandering in the alluvial fans produced by the bluff streams along the east side of the lower Yazoo.
3. Contact has been made with the United States Forest Service, Tallahatchie Branch Experiment Station, Oxford, Mississippi for correlation of activities and cooperation in the work.
4. Much time has been spent with Mr. W. L. Heard, in charge of the Tallahatchie-Yazoo Flood Control Project, New Albany, Mississippi, and his Assistant, Mr. A. C. Alnutt. This is premised upon the thought that the Sedimentation Research Project can perhaps achieve its maximum usefulness through securing greatly needed information on rates of sediment for the Flood Control staff and in the evaluation of the effectiveness of measures instituted by the Flood Control staff.

5. Plans were made for a detailed study of rates of sediment production in the two following ways: (a) extensive surveys are planned for the so-called "Plugged Gully" near Oxford, Mississippi. Degradation gages or concrete plugs were established in this gully by the Stream and Valley section of Soil Conservation Research in 1936. (b) The Debris basins constructed by the Flood Control organization at New Albany, Mississippi throughout the Yazoo Basin will be made a subject for exhaustive investigation for rates of sedimentation collection above them and for degradation rates below them.

Hastings, Nebraska, John A. Allis, Project Supervisor.

Ten years of hydrological data is available on the Central Great Plains Experimental Watershed, near Hastings, Nebraska. These results are especially valuable because all precipitation can be accounted for as evaporation, transpiration, soil moisture, or runoff. No surface water enters the ground water, which lies at a depth of 40 to 120 feet, because of the deep loessial deposit, also no accretion to stream flow comes from the ground water, thus eliminating a factor of major concern in studying runoff from agricultural areas.

In the past 10 years it has been found by hydrographers that runoff is not a coefficient of rainfall, but that many factors intercede to determine peak rates and total amount of runoff. The best approach in making an analysis is believed to be by probability methods. In August, 1948, a publication "Rates of Runoff for the Design of Conservation Structures in the Central Great Plains of Nebraska and Kansas" was released, which uses the latest method of analysis.

Results in 1948, on 4 acre watersheds, farmed under field conditions show the following:

1. For five storms during the year the total runoff was reduced considerably for corn, oats and wheat planted on the contour and by subsurface tillage as compared to straight row farming.
2. For the period April 1, to September 30, 1948:
 - a. The total runoff from straight row corn was 1.46 inches, which was almost twice the total runoff from subtilled and three times as high as contour listed corn.
 - b. The runoff from straight row small grains was about 1.4 inches, which was more than double the runoff from subtilled and almost 40% higher than contour small grains.

3. Storm of July 18, 1948 (0.93 inch of rain in 16 minutes at the Meteorological Station).
 - a. The average peak rate of runoff of 3.28 inches per hour from corn, straight row listed, was reduced almost half by contour listing, and almost two-thirds by subsurface tillage.
 - b. The average peak rate of runoff of 3.60 inches per hour from straight row oats was reduced a third by contouring and subsurface tillage.
 - c. The average peak rate of runoff of 3.02 inches per hour from straight row wheat (oats substituted for wheat on these watersheds for 1948) was reduced one-tenth by contouring and two-fifths by subsurface tillage.
4. Yields of oats were practically the same for sub-tillage and straight row with a slight increase for contouring.
5. Yields of sub-tilled corn was 29.7 bushels per acre, which was one bushel per acre more than the contouring and 6.7 bushels more per acre than straight row corn.

The following can be said of pasture plots for the period, April 1 to September 30, 1948:

The total runoff from eccentric disked plots was less than a third, and the contoured furrowed pasture plots with 12 to 16-foot horizontal spacings was less than one-sixth of the runoff from plain pasture. Furrowed plots with 5-6 foot horizontal spacings showed only .006 inch of runoff for the period.

Lincoln, Nebraska, Louis M. Glymph, Jr., Project Supervisor.

This project was established with headquarters at Lincoln, Nebraska, on November 15, 1948. Its purpose is the investigation of the nature, causes, effects, and control of sedimentation in the Missouri River Basin.

Since the project was established late in 1948, the investigations were only getting started by the close of the year. This report, therefore, deals more with the objectives and procedures of the project than with accomplishments to date.

The principal objectives of the project may be summarized under the following three headings:

1. Development of methods, techniques, and procedures for deriving sediment-production indices (long-term mean rates of sediment production per unit area under existing conditions of land use) for all significant physical land units and sub-basins within the Missouri River Basin.

2. Development of techniques and field methods for determining sources of damaging sediment in all sub-basins of the Missouri River Basin.
3. Development of procedures and criteria for designing, and evaluating the effectiveness of sediment control measures such as check dams, debris basins, channel stabilization, etc., with relation to sources of sediment in sub-basins of the Missouri River Basin.

Consideration is being given initially to development of methods, techniques, and procedures for deriving sediment production indices. It is believed that sufficient data have been assembled on the amount of sediment accumulation in reservoirs and the amount of sediment passing stream measurement stations throughout the Basin and in adjacent similar areas to make possible at least the beginning of a search to find and define in mathematical terms those factors and combinations of factors most important in producing sediment. As a first step in this direction all pertinent sediment records are being compiled, both from reservoir sedimentation surveys and suspended-load measurement stations.

Information at hand indicates that, to date, sedimentation surveys have been made on about 90 reservoirs and stock ponds in the Basin and adjacent areas considered as probably representative of conditions in which the amount of sediment was determined through standard detailed reservoir sedimentation survey techniques. The remainder are reconnaissance survey results of less reliable accuracy than the detailed survey results but still valuable as indicators of rates of sediment production.

Available records show that suspended-load measurements have been made, or are currently being made, at 219 locations throughout the Missouri Basin. Measurements are now being made at 134 of these stations. The number of suspended-load records from stations in areas adjacent to the Missouri Basin which may be applicable within the area has not been determined, but a significant amount of additional pertinent data may be available from this source.

The data assembled from these sources will be reviewed for accuracy of record, corrected where necessary, adjusted to reflect long-term averages, classified according to degree of accuracy and reliability and all expressed in comparable terms as a long-term rate of sediment production.

It is known that a great many factors combine to influence the amount of sediment reaching any particular point within a watershed or the rate of sediment production from any particular unit or sub-basin of a watershed. Some of the more important of these factors are: size of watershed or net contributing area; slopes of the watershed and position of slopes with respect to stream channels which are the avenues of sediment transportation; soils characteristics such as

parent material, permeability, erodibility, aggregation, and degree of erosion; land use including the amount of cultivated land, cultural practices, kind and density of cover; kind, degree, and density of channel development; climatic factors such as the amount, intensity, and frequency of rainfall; and, associated closely with all these factors, the amount and nature of runoff.

A great store of information on watershed features has been accumulated through geology, soils, erosion, land use, cover, and topographic surveys, aerial photography, rainfall and runoff measurements, and other lines of work, but in most cases such data have not been compiled and brought together for the watersheds above sediment measurement stations or reservoirs covered by sedimentation surveys. Such information for all watersheds on which reliable sediment records are available will be assembled and expressed in quantitative terms suitable for analysis.

As a final step in evaluating the significance of existing sediment records the combined information on sediment measurements and watershed characteristics will be subjected to rigorous statistical analysis and study. Through this approach it is believed that the factors affecting sediment production most significantly can be isolated and their function expressed quantitatively. The study should make possible the development of procedures for estimating sediment production indices from information on watershed characteristics. Such a procedure would be an invaluable tool for predicting the amount and rate of sediment production from portions of the basin where no sediment measurements have been made.

To some extent research in the other objectives of the project can be carried on concurrently with the work in deriving principles affecting sediment production. These objectives will be advanced to the extent possible as the other work progresses.

Raleigh, North Carolina, Ellis G. Diseker, Project Supervisor.

Summary of Bethel Experiment.

This is a progress report and the results are tentative; therefore, they should be treated as such. The data contained herein are for two periods including that from January 1 to February 21 and that from July 14 to December 24, 1948.

The types of drainage that were tested on Eladen silt loam soil and nine other closely related soils consist of the following:

1. 4" diameter tile drains at 2-, 3- and 4-foot depths, with spacing of 50, 75 and 100 feet for each depth.
2. Blasted ditches.
3. Open ditches with spoil banks in place.
4. Open ditches with no spoil banks.

These ditches are all approximately 3 feet deep and each has a spacing of 50, 100, 150 and 200 feet, except the 150-foot spacing of blasted ditches which was eliminated this year.

5. V-ditches, 1.5 feet deep.
6. Single bed drains, 1.0 foot deep.
7. Double bed drains, 1.0 foot deep.

Both single and double bed drains have spacings of 60, 90 and 120 feet. V-ditches have spacings of 60 and 90 feet.

Again for the second year there was no outstanding difference in the drainage effects from the different spacings on any of the various types of drainage. However, the effect in general was progressive or about proportionate and slightly decreased the depth of drainage when the spacing increased. The type of drainage and its depth of installation was the most important factor affecting the water tables.

Open Ditches and Tile 3 Feet Deep.

For the second consecutive year, all open ditches 3 feet deep, including blasted ditches, ditches with and without spoil banks, also tile at 3-foot depths, were the ranking four systems of drainage tested. Tile 3 feet deep gave the lowest average water table of all systems even though on one occasion the water was .16 of a foot below the surface 24 hours after a particular rain. With this exception, and once when the table was .7 of a foot deep in the blasted ditch areas, the above systems lowered the table 1 foot or more below the surface within 24 hours after cessation of rains.

Spoil Banks. Again spoil banks had no noticeable effect on drainage.

Tile 2 Feet Deep.

Tile drains 2 feet deep again were slightly less effective in lowering the water table than the systems just described above. In all instances except three, the water table was lowered more than 1 foot below the surface 24 hours after rains.

Check Plot.

The check plot enclosed by open ditches 2.44 feet deep, spaced 250 feet apart, ranked about on par with the 2-foot depth tile.

Tile 4 Feet Deep.

Tile installed to a depth of 4 feet gave an average satisfactory low water table but in addition to the three tables above the surface, there were seven other periods when the table was above the surface during November and December. This could not be considered satisfactory drainage. Tile at 4-foot depths is definitely too deep in the impervious Bladen subsoil. Possibly this area would respond well to tile at 2-1/2- or 3-foot depths.

V-ditches.

On an average, V-ditches 1.5 feet deep lowered the table 1 foot in 24 hours. However, on two occasions the table was on the surface and on four occasions it was about .5 of a foot below the surface.

Bed Drains.

Both single and double bed drains 1 foot deep gave poor drainage even though the table averaged 1 foot below the surface. This was due to the fact that the water table was above or near the surface on eight occasions.

Crop Yields.

Though corn yields were not measured, observations indicated that yields were reduced some by dry weather during a major portion of the growing season. The heaviest precipitation which produced high water tables occurred before and after the crops were produced.

Summary of Plymouth Experiment.

As in the case of the Bethel Experiment, this is a progress report and the results are tentative, therefore they should be treated as such. The data contained herein are for two periods, including that from January 1 to February 21 and that from June 13 to December 30, 1948.

The different types of drainage were tested on Bladen silt loam soil including one 3-acre area of Bayboro soil. These types are listed below:

1. Four-inch diameter tile drains, installed at 2-, 3-, and 4-foot depths with spacings of 50, 75 and 100 feet apart for each depth.
2. Blasted ditches.
3. Open ditches with spoil banks in place.
4. Open ditches with no spoil banks. All open ditches are approximately 3 feet deep, including the blasted ditches, and each has a spacing of 50, 100, 150 and 200 feet apart. There is one extra spacing of 230 feet without spoil banks.

5. V-ditches 1.5 feet deep.
6. Single bed drains 1.0 foot deep.
7. Double bed drains 1.0 foot deep.

V-ditches and both types of bed drains have spacings of 60, 90 and 120 feet apart for each. Again for the second consecutive year, there was no outstanding difference in the drainage effects from the different spacings on any of the various types of drainage even though the effect in general was progressive or about proportional and slightly decreased in depth of drainage when the spacing increased. The depths of installation and the types of drainage were the most influential factors affecting the water table.

The effect of spoil banks on drainage was insignificant.

Drainage data from the Plymouth Experiment are relatively uniform or more consistent than that at the Bethel Experiment because the soil is more uniform at Plymouth.

Since spacing was not a major factor, in that depth of drainage was satisfactory for the maximum spacing, and drainage was almost as efficient as that for the minimum spacing, it is believed that the maximum spacing to which the soil will efficiently drain has not been reached at the Plymouth Experimental area.

Coshocton, Ohio, L. L. Harrold, Project Supervisor.

Effect of Contour Tillage.

Contour tillage of corn on 15 percent land slope reduced runoff 60 percent and erosion 67 percent where sod waterways were used. Where there were no sod waterways the contour cornland reduced runoff only 17 percent and there was no reduction of erosion. Runoff and erosion measurements were made on farm fields of about 3 acres - straight-row farming versus contour farming. Sod waterways cannot be neglected.

Erosion in the sloping furrows of straight-row cornland was very great for the first two or three storms after cultivation. This increase was not noticeable in the contour cornfield. For those storms occurring first after cultivation, the effect of contouring plus sod waterways was to reduce soil loss 77 percent. Later on, after the soil surface was packed and hard, the erosion in the sloping rows diminished. Consequently, the effect of contouring when soil was packed reduced erosion 32 percent.

Mulch Culture in Cornland.

By far, the best soil- and water-conservation job in cornland has been accomplished by mulches. Table 1 gives the data for 1948.

Table 1.—Effect of mulch in cornland watersheds,
May - September 1948

| Tillage | : <u>Runoff</u> :: | | : <u>Soil loss</u> | |
|-----------------------|--------------------|------------------------|-----------------------|------------------------|
| | : Amount Inches | : Reduction Percent | : Amount Tons/acre | : Reduction Percent |
| Plowed, straight rows | 2.86 | 0 | 23.0 | 0 |
| Plowed, contour rows | 1.14 | 60 | 7.8 | 67 |
| Mulch, contour | .05 | 98 | .027 | 99.9 |

Good corn yields can be maintained by mulches on well drained soils if the nitrogen content is high. Corn yields of 90 to 106 bushels per acre have been obtained where good alfalfa-grass sods have preceded corn. In most cases the mulch areas have out-yielded the plowed areas. Where nitrogen was deficient corn yield in mulch area was 12 bushels less than plowed corn.

Hydrology of Chemical Weed Control in Cornland.

Where chemicals (2,4-D) were used to control weeds in plowed corn-fields and no mechanical cultivation performed, soil surface became sealed and runoff and erosion increased (table 2).

Table 2.—Runoff and erosion from cultivated and non-cultivated watersheds, July 1948

| Culture (both areas on contour) | : <u>Runoff</u> : | | : <u>Erosion</u> | |
|------------------------------------|--------------------|-----------------------|-----------------------|-----------------------|
| | : Amount Inches | : Increase Percent | : Amount Tons/acre | : Increase Percent |
| Plowed, cultivated | 0.41 | 0 | 1.55 | 0 |
| Plowed, no cultivation, 2,4-D used | .92 | 124 | 2.05 | 32 |

Cultivation in cornland through June and early July broke up surface crust of soil thus aiding water absorption. Less runoff meant less erosion. Where the crust remained undisturbed, its capacity to absorb water diminished. Runoff and erosion increased.

Observations on one year's experiment indicate that the following procedure may be desirable on hill land:

1. Use chemicals early - pre-emergence.
2. Omit the usual first cultivation.
3. Cultivate for weed control and breaking up of surface crust when needed thereafter.
4. Possible application of chemical for weed control after last cultivation.

Use of Pore Space in Soil for Conservation.

September soil studies indicated large quantities of empty pore space in the soil available to take up water (table 3).

Table 3.--Available pore space in various depths of soil on meadow and cornland, September 17, 1948

| Depth Inches | Meadow (well drained) Inches | Meadow (slowly permeable) Inches | Corn (well drained) Inches |
|-----------------|------------------------------------|----------------------------------------|----------------------------------|
| 0-1 | 0.43 | 0.41 | 0.43 |
| 0-3 | 1.30 | 1.28 | 1.31 |
| 0-5 | 2.18 | 2.17 | 2.20 |
| 0-7 | 3.07 | 3.08 | 3.09 |
| 7-14 | 2.79 | 2.95 | 2.51 |
| 0-14 | 5.86 | 6.03 | 5.60 |

Prior to storm of September 19-20, the top 3 inches of soil could absorb 1.3 inches of water. All of the 1.1 inches of rain September 19-20 was absorbed by the meadow watersheds and the mulch cornfield. Less than two-thirds of this rain was absorbed by the plowed cornfield in straight-rows. Over one-third ran off carrying almost one-half ton of soil per acre.

Many large storms use up all the storage space in the topsoil (0-7") quickly. Thereafter, subsoil storage space is used as fast as water can be transmitted into it. This rate is only one-third or one-fourth as fast as that in the topsoil. Consequently, the pores fill up slower, water movement into the soil surface is retarded, and runoff occurs. Still empty pores are found in the root zone.

In order to use storage space in the ground for soil and water conservation:

- A. Surface in clean cultivated fields must be mulched to prevent sealing.
- B. Permeability of soil below plow layer must be increased to transmit water to lower depths of the root zone.

Studies of water movement into and within soils show the influence of soil type and vegetal cover on this movement (table 4).

Table 4.--Infiltration of water into soil and rate of movement through soil

| Soil drainage | Cover | Maximum infiltration capacity at soil-moisture content of: | | | | Maximum transmission rate (linear velocity) | |
|--------------------------------|--------------------------|------------------------------------------------------------|--------|--------|--------|---------------------------------------------|-------------|
| | | 0.20 | 0.30 | 0.40 | 0.50 | 0-7" depth | 7-14" depth |
| | | In/hr. | In/hr. | In/hr. | In/hr. | In/hr. | In/hr. |
| Well drained (Muskingum L.) | Forest, mature | 12 | 8 | 4 | 0.8 | 40. | 15. |
| Well drained (Muskingum S. L.) | Wheat, meadow or pasture | 6 | 4 | 2 | .08 | 20. | 6.7 |
| Slowly permeable (Keene S. L.) | Wheat, meadow or pasture | 6 | 4 | 2 | .04 | 20. | 5. |

1/ Moisture content expressed in inches of water per inch of soil. 0.51 is saturation.

Water will move into and through cultivated soil about half as fast as mature woodland soil until saturation is approached. Then the well-drained cultivated soil takes up water only one-tenth as fast as mature woodland and the slowly permeable cultivated soil one-twentieth as fast.

Deep Tillage.

Air space below the plow layer will have to be used for water storage if the soil and water conservation job is to be improved. Soil tilled the ordinary 7-inch depth on a conservation field could absorb only 0-7 inch of water before runoff and erosion started (Feb. 13, 1948 storm). Soil tilled 9 inches deep (only top 4 inches turned over) absorbed 40 percent more water before runoff and erosion started (same storm).

Deep tillage with applications of lime and fertilizer have promise of effectively increasing our depth of topsoil. From a hydrologic standpoint, this means less water for floods and more water for crops. Much study needs to be done on this problem.

Water Conservation on Land Surface Aids Dry-Weather Stream Flow.

Proper land use reduced surface runoff on farm land, increased soil and ground water and lengthened the duration of seepage flow in streams.

Table 5.--Surface runoff rates and amounts from fields in different use, 1948

| Land use | Runoff | | :Number of : days of : runoff |
|--------------------------------|----------------------|-------------------------------------|-------------------------------------|
| | : Total: : Inches | : Maximum rate : Inches per hour | |
| Small areas less than 3 acres: | Inches | Inches per hour | |
| Woodlot (well drained soil) | 0.17 | 0.06 | 4 |
| Pasture | 1.19 | .42 | 13 |
| Cultivated | | | |
| corn - straight row | 3.61 | 3.90 | 39 |
| corn - contour | 2.41 | 1.77 | 36 |
| corn - mulch | .79 | .17 | 11 |
| wheat - no manure | 2.64 | .53 | 38 |
| wheat - manured | 1.14 | .31 | 24 |
| Larger areas: | | | |
| Woods (43.6 acres) | 10.66 ^{1/} | .15 | 335 |
| Mixed cover (75.6 acres) | 7.33 ^{1/} | .19 | 154 |

^{1/} Mostly seepage flow.

Surface flow occurred in woodland on only 4 days in the year. In this area about 30 percent of the rainwater that was absorbed into the ground seeped out into the stream at lower elevations. In the main stream from the 43.6-acre woodland, flow persisted for 335 days of the year. Never was the flood peak great. Nor did this seepage flow carry suspended material to a noticeable degree.

Surface runoff in straight-row cornland occurred on 39 days in flash flows. Erosion was severe. The main stream from a larger (75.6 acres) mixed cover area flowed for 154 days. Most of the 7.33 inches of runoff was seepage flow.

Flood Runoff.

Floods on small agricultural areas are of consequence in the growing season. Floods in the large rivers of the nation are serious in the dormant season (table 6).

Table 6.—Seasonal occurrence of floods in the Ohio River Basin

| Drainage area Square miles | : Maximum annual floods occur during - | |
|-------------------------------|----------------------------------------|--------------------------------------|
| | : May - September Percent of time | : October - April Percent of time |
| 1 | 99 | 1 |
| 10 | 87 | 13 |
| 100 | 66 | 34 |
| 1,000 | 26 | 74 |
| 10,000 | 10 | 90 |
| 100,000 | 5 | 95 |

Roughly speaking, on areas of 10 square miles, 90 percent of the maximum annual floods are in the growing season. On areas of 10,000 square miles, ninety percent of the maximum river floods annually are in the dormant season. Almost without regard to the size of drainage basin, the season of most soil loss is in the growing season.

Contour Fences.

One year of observations using woven wire fence and steel posts on contour lines show:

1. Construction is not difficult. It was easier to stretch fence on the curve line than it was that on a straight line - especially where dips and rises were encountered.
2. Less tension is needed to lay up curved fences than those in straight lines. Possibly, much of the difficulty with curved fences in the past is that farmers have stretched the curved lines as tight as their straight-line fences. This gives too much pull on the posts and is unnecessary.
3. All posts evenly spaced on smooth curves will have the same pull - no one post will be bent over excessively.
4. Rod spacing of posts is satisfactory on gentle curves. Shorter spacing will probably be necessary for sharper curves. Additional studies will develop these specifications.

5. In one year, the posts have shifted their position slightly and the tension in the curved line fences has slackened somewhat. Neither of these changes are apparent without careful measurement.

Training Center.

Starting in July, this experiment station has been used by SCS Operations as a Training Center for new SP employees in Region III. Five groups, of 16 men each, spent a 3-week period at this Center. Operations personnel formed the teaching staff. The Research project supervisor spent about 6 hours each period presenting research activities, findings, and objectives.

The men in each group were housed and fed on the station. Comments from the trainees and from Operations personnel indicated rather complete satisfaction with the facilities. On the initiative of Operations officials in Region III, plans were laid to move the Professional Training Center to this research station.

Stillwater, Oklahoma, W. O. Ree, Project Supervisor.

Vegetation Lined Channels.

Tests were made on a channel while it was thawing out from a previous freeze. It was expected to be at its weakest at this time. The channel tested had a vegetal lining of mixed grasses, including little bluestem and Bermuda grass. The results of the experiment indicated a permissible velocity of about 3 feet per second. This is considerably less than the permissible velocity of 5 feet per second for a summer time cover.

Tests on bunch grasses showed that erosion takes place between the clumps. This material is deposited downstream of the bunches of vegetation. In some cases this deposition was 3 inches deep for a single test. As a result the channel bed tends to grow rougher and more irregular. Keeping the cover mowed would help this condition.

Burning experiments were continued this year. Two bunch grass channels were burned and tested. These were a little bluestem channel and a weeping lovegrass channel. After burning the channel beds were covered with the large base clumps. The retardance of this lining was relatively low, permitting high velocities to develop. The clumps caused excessive turbulence increasing the erosion damage. As a result the permissible velocities were around 1-1/2 feet per second. Burning is an unsafe practice for vegetation lined waterways.

A new species, the splitbeard bluestem, was tested this year. It shows promise as a good channel lining. While it is a bunch grass, the clumps are small and the coverage of the channel bed rather complete. Its permissible velocity is about 4 feet per second. Its retardance is between classes C and D.

Observation on one channel over a five-year period show the occupying species of grasses to be changing. Originally the cover was a nearly pure stand of Bermuda grass. Today the cover is only 1/3 Bermuda grass. The volunteering species include miscellaneous annuals, and some bluestem. As a result the permissible velocity has dropped from 8 feet per second to 6. The retardance has increased.

A new retardance class E has been established to include covers less than 2 inches in length. A diagram solving Manning's formula for this retardance class has been prepared.

Waco, Texas, Ralph W. Baird, Project Supervisor.

With additional funds available since July 1948, the work has been expanded and analyses of old data are now in progress, although not yet in form to present in this report. Runoff tabulations and computations through 1948 are completed for all stations now in operation. These data are now being used in the analysis of the effect of conservation practices on flood flows. The few storms of 1948 gave quite good checks with previous analyses on peak rates of runoff for watersheds of about one hundred and fifty acres. Analyses for areas of other sizes are under way. Preliminary studies on the effect of conservation practices indicate that on areas of 150-300 acres the suspended matter carried in runoff water is reduced to about twenty percent of that expected with ordinary farm practices. Conservation practices continue to show increased yields; with cotton from nineteen to forty-three percent increase, with corn from twenty-five to thirty-one percent increase, and with oats a six percent decrease in grain yield, but with a crop of Hubam clover turned under as green manure after harvest of the oats. Cooperative work with the Bureau of Entomology and Plant Quarantine on the effect of conservation practices on populations of injurious insects has been continued and will be reported by the Bureau of Entomology and Plant Quarantine.

Blacksburg, Virginia, T. W. Edminster, Project Supervisor.

Hydrologic Project.

Blacksburg, Virginia. The bulletin "Rates of Runoff in the Ridges and Valleys of Virginia," T. W. Edminster and J. H. Lillard (SCS-TP-67) was published in May 1948. This publication was based upon the first seven years of data from the Blacksburg watersheds. Analysis is

under way on expected yields of runoff under various cover and tillage conditions in order to supply much needed data for water storage problems.

Bell Creek, Staunton, Virginia. Three watershed gaging studies were established in 1948 on 440, 2,200 and 6,000-acre watersheds on Bell Creek near Staunton, Virginia. These watersheds, operated in cooperation with the SCS Flood Control staff and the United States Geological Survey, are designed to provide data on intermediate sized areas.

Chatham, Virginia. The first ten years of operation of these three small terraced watersheds have been completed. The installations were revised in December to provide peak rate data only together with continuing rainfall intensity data.

The data from this study will be analyzed for publication in the near future.

Farm Ponds.

The objective is to determine practical and economical methods of providing a water impervious soil mantle over the area of prospective pond sites which are needed to facilitate proper land use. The highly soluble limestone underlying many soils of this area demands a 100% seal as insurance against sinks or cave-ins of the supporting strata beneath a pond. The initial study considered soil alone, without additives, as a material of construction. Factors investigated were: thickness of soil mantle, compaction of the soil, and head of water to be held.

Average percolation rates of ten soils of various thicknesses after compaction and under varied heads of water

| Mantle Thickness Inches | Compaction Load | | | Head of Water | | |
|----------------------------|-----------------|-----------|-----------|---------------|--------|--------|
| | 50#/s.i. | 100#/s.i. | 150#/s.i. | 7-1/2 ft. | 15 ft. | 30 ft. |
| | in/hr. | in/hr. | in/hr. | in/hr. | in/hr. | in/hr. |
| 6 | .342 | .096 | .032 | .017 | .114 | .339 |
| 12 | .184 | .077 | .023 | .013 | .067 | .204 |
| 24 | .085 | .024 | .008 | .004 | .020 | .094 |
| 36 | .029 | .014 | 0 | 0 | .012 | .031 |

The literature and work on this project indicate that any soil of sufficient thickness can be rendered impervious by proper compaction at optimum moisture. These requirements are readily practicable in pond construction.

There is a very definite optimum moisture at which each soil can be compacted to a maximum density. It is that condition too wet for

good tilth but not wet enough to exude water during compaction under desired load.

Dispersion agents did not completely seal those soils tried in the laboratory and dispersed soils could not be permanently compacted but loosened up again overnight.

Bentonite successfully sealed the five soils studied thus far. If supplemented by 50#/s.i. compaction load, the soils usually need less bentonite than they did when merely puddled. There is quite definitely an optimum application of bentonite for each soil below which it will not seal and above which the soil stability is decreased and will not support larger heads of water. Optimum applications for these five soils ranged from .75 lb. to 1.5 lbs/sq.ft. mixed to a depth of five inches.

A very limited study of algae cultures did not reveal any reduction of permeability due to algae.

Drainage Project.

Permeability. The 44 soil permeability determination sites sampled in Virginia in 1948 include 32 soil types. According to geographical location, 22 are in the Piedmont, 7 in the Coastal Plain, and 3 in the Limestone Valley.

In the laboratory, for each core taken, the rate of percolation, water drained in 15 minutes, water drained in 15 hours, and volume weight were determined. The averages for the several determinations for each soil horizon sampled for each site are reported on the mimeographed Permeability Determination for each site.

During the first part of the year some comparisons of the results for 3" cylinders vs. 4" cylinders, driving vs. jacking, and the tension plate vs. tension pan were made.

During the latter part of the year the 3" cylinders were driven and the tension plate used.

Beginning at the end of 1948 and being carried over to 1949 is a comparison of cutting heads of different composition and lengths.

Draw-Down-Curve Studies.

Field studies of the relationships of soil permeability and soil water-table draw-down were started and are now in operation in two soils drained by open ditches, two by tile systems, and two by pump units (simulated tile drainage). Studies on open ditch and tile drainage systems were designed as a means to evaluate the effectiveness of

current drainage practices and recommendations. Studies on pump unit systems were designed to obtain drainage characteristics upon which to calculate different recommendations and practices.

Continuous water-table and rainfall records are being collected through the use of recording gages. It has been found that more accurate rates and degrees of water-table draw-down and relationships of precipitation and water table fluctuations can be interpolated from recording gage records. Need for more detailed study of depths to place tile in the soil was indicated from pump unit studies.

Present trends show little or no movement of tile in the "soft sand" layer of soil. The amount of sediment collected in the lateral lines has fluctuated considerably since May 1947 (initiation of study). Laboratory studies are scheduled to analyze samples of the sediment to determine the nature of the material in the lines.

Irrigation.

An increase in yield of alfalfa of about 17% was obtained by supplemental irrigation under the conditions existing at the McPherson site. However, it appears that an increase in yield of alfalfa of about 25% is necessary to show a profit from irrigation for any one year. Over a period of years, this value may possibly be lowered.

The pasture irrigation study was set up and calibration trials were run. This project will be ready for study this coming year. Arrangements have also been made to establish a series of plot studies on the effect of irrigation in a corn, wheat, clover rotation, on alfalfa and on a burley tobacco rotation.

Pasture Fertilization.

This project was planned and installed to study the effect of phosphate fertilizer applied at different depths (2-1/2" and 5") and spacings (8" and 16") and various combinations of surface and subsurface applications to permanent pasture. It is also planned to determine the machinery requirements for the most efficient fertilizer placement on pastures.

Since this is the first year of the study, no yield data is available. It appeared, however, that the effect of scarification is minor when sufficient rainfall follows to compact and seal the rupture in the sod.

Madison, Wisconsin, N. E. Minshall, Project Supervisor.

Fennimore, Wisconsin.

The manuscript entitled "Rates of Runoff for the Design of Conservation Structures in the Upper Mississippi Valley Upland Loessial Areas," covering recommended values based on the first ten years of records, was approved for publication. Some of the material in this report has already been made available to the Regional Engineering Section and to the Bridge Department of the Wisconsin Highway Commission. The data included should be of considerable value in farm planning and flood control work within the area to which the studies are applicable.

The existing studies must be continued for a number of years to verify the preliminary design values, and they should also be expanded and enlarged to include additional information, more soil types and a greater range in size of areas.

Wisconsin Valley Hydrologic Project.

A new runoff measuring station was established on a 350-acre area near Colby, Wisconsin, and collection of records begun in September. The cost of construction and observation on this area are the contribution of the Wisconsin Valley Improvement Company, as their part of the co-operative project. Equipment and technical supervision are furnished by the Soil Conservation Service, Research. Observations on this area include precipitation, runoff, crop cover and soil moisture.

Evaluation of Erosion Control Structures in Wisconsin.

Thirty-five drop inlet structures were examined and found to be in satisfactory condition. This number is too small and the study is not sufficiently complete to enable drawing general and sweeping conclusions. Only a minimum amount of hydrologic data can be obtained through the farmers interviewed.

SUMMARY OF ANNUAL REPORTS FOR CALENDAR YEAR 1948

R-3 IRRIGATION AND WATER CONSERVATION DIVISION

WATER REQUIREMENTS FOR IRRIGATION

This work project includes (1) Determination of Irrigation Requirements, (2) Methods of Water Application, (3) Relationships of Water Supplies to Irrigation Practices, (4) Evaluating Irrigation Water Supplies for Selected Areas.

Irrigation Practices, Evapo-Transpiration and Rainfall Penetration as They Affect Irrigation Water Supplies. (California) (Dean C. Muckel)

Rainfall and irrigation water penetration studies were completed and a progress report prepared for Chino Basin, the largest and most important of ten ground-water basins, which combined make up the Upper Santa Ana River Valley. In this report, data and information were presented on transpiration by eleven different irrigated crops, eight non-irrigated and native plants, initial fall soil moisture deficiency, penetration of rainfall and deep penetration of irrigation water. Data and information were also presented on consumptive use of water by non-economic plant growth along the valley floor of the Santa Ana River in an area of high ground water. The consumptive use (water loss) here amounts to about 18,000 acre-feet per year and approximately one-half is believed to be salvagable for beneficial use.

In the Yucaipa-Beaumont area, evapo-transpiration studies on a mature peach orchard showed the trees transpired 14.43 acre-inches of water out of a total of 18.4 acre-inches applied in irrigation. The remaining water was lost through evaporation from the soil surface and in penetration below the root zone.

One of the problems here is how best to irrigate to get the most out of the available water supply. The supply is exceedingly limited and there appears to be too little water available for all lands to be irrigated for maximum production.

Water Requirements in Irrigated Areas. (California) (H. F. Flaney and Wayne D. Criddle)

The present studies were initiated in 1947 as the result of requests from the western regional offices of the Operations Division, Soil Conservation Service, and State agencies for more concise information

on water requirements of different crops in connection with farm planning and water conservation programs. The project is being conducted in cooperation with western State engineers, State Agricultural Experiment Stations and/or Operations Division, Soil Conservation Service.

During 1948 the outstanding development of this study was the determination of the rates of water consumption by agricultural crops and natural vegetation in the irrigated areas of the Upper Colorado River Basin at the request of the Upper Colorado River Basin Compact Commission, which consists of representatives of the States of Arizona, Colorado, New Mexico, Utah and Wyoming, and the U. S. Bureau of Reclamation. A provisional report entitled "Consumptive Use of Water Rates in the Upper Colorado River Basin" was completed, after a field study of irrigated areas in the Basin, by Harry F. Blaney and Wayne D. Criddle with the assistance of the Engineering Advisory Committee of the Commission and local representatives of the Soil Conservation Service, Bureau of Reclamation, State Engineers and County Extension Agents. Information on consumptive water requirements was needed before the waters of the Colorado River in the Upper Basin could be divided among the five states under a compact. The total quantity of water available to the Upper Basin is limited to 7,500,000 acre-feet per year.

The report of Blaney and Criddle was accepted by the Compact Commission and it was employed to estimate the total valley consumption of water resulting from irrigation development in each state. On October 11, 1948 the Commission signed the Upper Colorado River Basin Compact apportioning water from the Upper Colorado River system to the five states involved, on the basis of consumptive use. After deducting 50,000 acre-feet per year for Arizona, the remaining quantity of water per annum was divided as follows:

| | |
|---------------------|---------------|
| State of Colorado | 51.75 percent |
| State of New Mexico | 11.25 " |
| State of Utah | 23.00 " |
| State of Wyoming | 14.00 " |

The Compact will not become effective until ratified by the State Legislatures and Congress.

Irrigation Practices and Water Efficiency Studies in Antelope Valley, Yucaipa and other Soil Conservation Districts. (California) (H. F. Blaney and V. S. Aronovici)

In the Antelope Valley, the analysis of field studies was completed in 1948. The more important findings are briefly discussed below.

Observations confirm that whenever irrigation systems comply with practices recommended by the Soil Conservation Service, excellent irrigation efficiencies are obtained. The study further emphasizes the importance of irrigation frequency to make the best use of irrigation water. When excessive amounts of available soil moisture remain in the soil at time of irrigation, efficiencies will be lowered. It is recommended that at least 50 percent available moisture be depleted from the first two feet of the soil profile before irrigation. Analysis of previously collected data dealing with production of alfalfa show, as might be expected, increased production with larger applications of water. This holds to a maximum of 7 acre-feet irrigation water per annum per acre. More significant is the finding that increased applications of water result in diminishing returns per acre-foot of water applied. For example, four acre-feet per acre of irrigation water produces 1.5 tons of alfalfa per acre for each acre-foot of water applied. However, nine acre-feet per acre produces only 0.6 ton alfalfa per acre foot of water applied.

During 1948, irrigation and water conservation studies in several soil conservation districts resulted in more efficient use of water through improved irrigation practices. For example, in the Yucaipa Valley Soil Conservation District, as the result of an overdraft, on the underground basins and the small amount of rainfall in 1947-48, there was a shortage of irrigation water. Soil moisture studies indicated that most efficient use of water could be obtained by changing the 21-day rotation irrigation schedule to a 14-day schedule with application of less water per irrigation; or a 28-day schedule with an application of more water per irrigation on half the orchard by alternate furrows.

Technical advice and assistance was given in other districts, when requested.

Los Angeles West Coast Basin Investigation. (California) (H. F. Blaney and V. S. Aronovici)

Field and laboratory study of soils as related to rainfall and irrigation water has been applied to the Los Angeles West Coast Basin. Working methods and field observation stations have been set up and observations continued intermittently throughout the year. Soil and land use maps are nearing completion. Laboratory analyses of soil characteristics was partially completed with wilting percentages measured for each fall deficiency station. Field soil moisture study has been delayed because of the very small rainfall in 1948. Weather station records have been collected and summarized for an 18-month period.

A serious water shortage exists in the West Coast Basin. Overdraft has resulted in encroachment of salt water from the ocean. It is highly important to industry and residents of this area that safe

yields and equitable adjudication of water supply be established. The Division of Irrigation and Water Conservation is cooperating with the State of California by determining contribution to the basin from rainfall and irrigation waters.

Irrigation and Water Conservation Studies in the Pajaro Valley.
(California) (Paul A. Ewing and H. F. Blaney)

The field and office work for the 1947-48 season was completed and a progress report prepared for the State Engineer of California and the Operations Division of the Soil Conservation Service.

The results of the irrigation practices study by Paul A. Ewing are as follows:

The irrigation practice chapter (by Ewing) describes methods of irrigation, numbers of irrigations, and amounts of water applied to each of the important crop types. A description of the soils (prepared by Operations Division) is included.

Tentative values of consumptive water requirements under normal irrigation and climatic conditions in Pajaro Valley for typical irrigated crops, as determined by Blaney, are shown in the following tabulation.

| Crop | Rates of consumptive use of water | | | Inches | Feet |
|-------------------|-----------------------------------|----------------------------------------|--------|--------|------|
| | Inches | Inches | Inches | | |
| | (November 1 to March 31) | Irrigation season (April 1 to Oct. 31) | Annual | | |
| Alfalfa | 9.0 | 28.7 | 37.7 | 3.14 | |
| Beans | 8.0 | 10.0 | 18.0 | 1.50 | |
| Berries (bush) | 8.0 | 10.0 | 18.0 | 1.50 | |
| Lettuce (2 crops) | 8.0 | 13.2 | 21.2 | 1.77 | |
| Pasture | 9.0 | 24.0 | 33.0 | 2.75 | |
| Sugar beets | 10.0 | 11.5 | 21.5 | 1.79 | |
| Tomatoes | 10.0 | 11.5 | 21.5 | 1.79 | |
| Truck | 10.0 | 10.0 | 20.0 | 1.67 | |

Rates of consumptive use were determined for other vegetative-cover classifications, such as dry-farm and native vegetation. These water consumption rates when applied to the different acreages of water consuming areas will provide the State Engineer with an estimate of total valley consumptive use, in acre-feet.

Water Costs and Utilization in Typical Irrigation Projects.
(California) (Paul A. Ewing)

Principal activity was the study of and reporting on the value of water for irrigation in Salinas Valley, California. This study and report were requested by the Corps of Engineers, Department of the Army, which carried the expense of the study under provisions of an informal agreement with the Division of Irrigation and Water Conservation.

The Corps of Engineers has in contemplation the construction of flood control works on the Salinas River system and, as required by law, wishes to take account of other benefits which might accrue from the building of the flood controls. Prominent among these other benefits would probably be the relief of pressure on irrigation supplies that are now almost entirely made available by pumping from wells. An appraisal of the value of water for irrigation was therefore needed, which it was thought I could make because of familiarity with the agriculture of the Valley and the prevalent irrigation practice as learned in the 1944-5 investigation made cooperatively with California State Division of Water Resources.

The Salinas Valley evaluation study was started and completed during the second half of the calendar year. It involved the cost and returns from farming in 1947 and, for a contrasting year, 1941. Value of water for irrigation was calculated for each of these years, as measured by the "net increase in value of crops (to the producer) realized through irrigation, per acre-foot of water applied to the soil."

Salinas Valley, while comprising an irrigated area of only 125,000 acres, is one of the most important agricultural sections of California, its prominence being due primarily to lettuce of which it is the nation's principal source of supply during spring, summer and fall months. This extreme specialization extends to other vegetable crops, and the climate and soils are such as to permit extensive double-cropping. In recent years, and especially in 1947, profits from the farming typifying the Valley have been very high, and since the possibilities of farming without irrigation are limited, the 1947 value attributed to irrigation was in the neighborhood of \$60 per acre-foot. In contrast, the 1941 value was only about \$7.50, that year being one of heavy rainfall, smaller production, and much lower prices.

Determination of Optimum Requirements and Methods of Application of Irrigation Waters in Texas. (Texas) (D. W. Bloodgood)

In Southeastern Texas, study of water requirements has been concerned particularly with the rice crop, which has expanded notably from 190,000 acres in 1940 to approximately 400,000 acres in 1948. Rice is therefore one of the largest irrigated crops in the State with an annual value of \$40,000,000. The water requirements for rice using pump water from wells averaged 3.11 acre-feet, while for water pumped from surface streams it amounted to 4.20 acre-feet. It is significant that the yield of rice using the smaller application of pump water amounted to 19-2/5 barrels per acre as compared to 14 barrels per acre for rice irrigated with the larger applications of river water.

A Comparison of Irrigation Water Application Efficiency on Level and Graded Runs. (Weslaco, Texas) (Emil Stuter)

The Weslaco office was opened on October 1, 1948 at the Texas Experiment Substation #15. The months of October and November were spent in ordering equipment and getting acquainted with the Lower Rio Grande Valley and its problems.

Objectives of Work in 1949:

1. To determine whether or not "level" irrigation is the most efficient method of gravity water application for the Lower Rio Grande Valley.
2. To initiate studies to determine the following:
 - a. The minimum hydraulic heads required on turnouts for level irrigation methods of water application.
 - b. The effects of crop rotations on rates of infiltration and permeability of soils under irrigation.
 - c. The effect of placement of crop residue on soil permeability and available moisture on irrigated soils.
 - d. The consumptive use of water by different crops.
 - e. Tolerances for level borders to give uniform distribution and highest water application efficiency for different soil units.

Irrigation Requirements and Water Application Methods in the High Plains Area of Texas and Their Effect on the Ground-Water Supplies of That Region. (Amarillo, Texas) (Norris P. Swanson)

A tentative program of irrigation research for the High Plains of Texas was formulated in late September 1948. The following agencies were represented: Texas Agricultural Experiment Station, Texas A & M College Extension Service, Agricultural Engineering Department of Texas A & M College, Texas Board of Water Engineers, Bureau of Reclamation, Soil Conservation Service Operations, and Soil Conservation

Service Research.

Offices were established at the Amarillo Conservation Experiment Station and the irrigation well was rehabilitated at the station. The balance of the year was spent in a study of previous irrigation and crop moisture requirement studies; plans were made for cooperative research on the Lubbocks substation of the Texas Agricultural Experiment Station. Tentative arrangements were made for off-station studies in cooperation with Soil Conservation Service Operations, and the first drafts of the project plans were prepared. Five irrigation training schools held by Operations at various locations were attended for short periods to obtain information on the most pertinent irrigation problems in different problem areas.

Infiltration of Water into and Permeability of Soils in an Irrigated Area. (Arizona) (Karl Harris)

During the year all the work done on this project was carried out on the University of Arizona farms at Mesa. This study has compared the effects of varying amounts of gypsum and sulfur, both alone and combined together, on water penetration. Manure and green manures have also been applied. So far soil amendments have shown little effect on the movement of water into the soil, while tillage and cultural treatment appreciably influenced the rate of infiltration. It was concluded also that less work was needed on seedbed preparation than is usually considered necessary.

Utilization of Limited Water Supplies for Greatest Economic Return. (Arizona) (Karl Harris)

The studies carried out have compared the efficiency of irrigation of alfalfa with annual applications ranging from 2 acre-feet up to a proposed maximum of 5 acre-feet. The actual applications ranged from 4-1/2 acre-feet up to 10-1/2 acre-feet for the irrigation year. Even with the larger applications, the soil moisture was reduced to the wilting point in all plots except those receiving the heaviest irrigation by early August. The value of moderate winter irrigations was shown in the elimination of hard spots due to poor infiltration. Yields of alfalfa hay varied from 7.4 tons per acre for the lowest irrigation up to 10.3 tons for the heaviest during the season.

Consumptive Water Use and Irrigation Requirements. (Utah)
(W. D. Criddle)

This study in the Ashley Valley and Ferron Area has been continued in cooperation with the State Engineer of Utah, the Utah Agricultural Experiment Station and the Surface Water Division of the U. S. Geological Survey. A complete classification of all the land use within each of the study areas has been made. All the crops were classified and mapped together with the native vegetation, water surface and other land uses. Nearly 35,000 acres of land were mapped in Ashley Valley of which less than 20,000 are irrigated. The total acreage mapped in Ferron Creek Area was slightly over 14,000 acres of which only 5,700 acres are irrigated.

The results of this study, together with other similar investigations, formed the basis for the recommendations made on the division of water of the Upper Colorado River between the five states of Wyoming, Utah, Colorado, New Mexico and Arizona.

HYDRAULICS OF IRRIGATION

This work project includes (1) pumping for irrigation, (2) flow of water in ditches, pipes and other irrigation conduits, (3) lining of irrigation canals and ditches, (4) control of silting in irrigation canals and ditches, and (5) design, invention and testing of irrigation and drainage apparatus.

Friction Losses in Pipes and Fittings for Pumping Plants. (Colorado)
(Carl Rohwer)

Further work has been carried out upon the analysis of friction losses through 4, 6 and 8-inch standard swing check valves. Certain discrepancies in the results were investigated and were found to be due to the improper assembly of a 6-inch valve. Corrected results were later obtained and tabulations of friction losses for a complete range of discharges for 4, 6 and 8-inch valves have been made available to pumping plant operators.

Performance Tests of Well Screens. (Colorado) (Carl Rohwer)

Work on the tests of the hydraulic characteristics of some 24 well screens of various sizes and types was continued during the past year. These tests showed that the flow through the continuous slot screens was much greater with the same loss of head than through screens with punched perforations. It was found that most of the water was entering the screens through the lower portion of most sizes under test.

Special sizes of gravel envelopes have been obtained and screened in 1-inch, 1/2-inch and 1/4-inch sizes. The final assembly of the gravel envelopes around the screens will be made early in the coming year. This information will be of notable value to pumping plant operators since it is essential that the water pumped be relatively free from sand in order to avoid undue wear upon pump parts and well fittings.

A General Formula for Flow in Pipes. (California) (F. C. Scobey)

To the large volume of United States data now available and prepared for analysis in the development of a basic formula for the flow capacity of new commercially smooth pipes, the project work has now added the results of Swiss and Italian observations on comparable pipe lines. The results of the San Diego test on concrete pipes have also been included. The new formula developed conforms to a remarkable degree for a wide range of sizes extending from 4 inches to 18 feet in diameter with transmission velocities from 1 to 50 feet per second. For concrete pipes, little difference has been found in the results for new or old installations. In other words, it is unusual to have a concrete pipe deteriorate in capacity. This is in contrast to the corrosion and tuberculation which ordinarily took place in iron or steel pipes. Recent developments in the interior coating of metal pipes either with hydrocarbons or with smooth coatings of cement linings have entirely changed this situation. These treatments promise to reduce notably, or prevent, the corrosion or pitting which formerly occurred in many types of metal piping. Hence, it is now possible to develop one general formula for the flow of water both in metal and concrete pipe lines.

A manuscript presenting the final results of a general formula for the flow of water in new commercially smooth pipes of all kinds has been prepared and it is hoped to present it for publication as a monograph in the Proceedings of the American Society of Civil Engineers. This will give the engineering profession the opportunity to test and criticize this formula in order that it may be tried under a wide variety of circumstances and tested for any possible revision which might be necessary.

Canal Linings. (Utah) (C. W. Lauritzen)

A survey was made of the State in an effort to locate earth materials which would be suitable for lining canals. A large number of deposits have been sampled and the physical properties of these materials determined. They may be classified into two general groups, soil material and bentonite. It has been found that the permeability

of most earth materials can be reduced to very low values by compaction at optimum moisture. The permeability of some soils and high swelling bentonites was found to be low for even uncompacted soil columns. In such a case soil permeability could not be reduced further by compaction.

During 1948 experiments with 16 earth linings in two channels at the River Laboratory were continued under test and observation. In addition a new channel with earth material mixtures has been installed. A fourth channel including asphaltic material, soil cement, stabilized earth and coated fabrics has also been put in place.

Installation of experimental canal linings in Richmond was completed. This project included the installation of 729 linear feet of concrete, 400 feet of shotcrete, 300 feet of precast concrete slab, 100 feet of gravel covered earth, and 300 feet of Butyl coated fiber-glass lining. Included in the various sections of the concrete lining were individual panels of concrete slabs. Both reinforced and unreinforced types were used with and without an air entraining agent. Three finishes were employed with two different thicknesses in various combinations.

Seepage measurements have been made in the 22-mile Provo River Reservoir Company channel, the Cub Irrigation Company in the Lewiston area and in several canals near Richmond and Logan, Utah. In addition, studies at the River Laboratory and in the Campus Laboratory have supplemented the field measurements.

The choice of lining material depends on many factors, probably the chief justification for attempting to employ earth for canal lining is the need to reduce the cost of lining. The low initial cost of lining with earth is in part offset by the higher maintenance cost to be expected and the larger channel which will be required to convey the same quantity of water. In the final analysis the availability of suitable earth materials in the immediate vicinity, together with the cost of other construction materials, should be a determining factor in the choice of type of lining.

Determination of the Characteristics of the Suspended Silt Load of Texas Streams. (Texas) (D. W. Bloodgood)

During the past year determinations of silt content have been continued at 24 different sampling stations. The demand for river water for irrigation is increasing in the State of Texas. This source of supply promises to be one of the most important factors in the future development of irrigation agriculture within the State. In order to insure constant supplies, storage reservoirs will be necessary. This will involve the problem of siltation and possible decrease of storage capacity. Therefore, silt studies and information as to the range

of content of solid material carried in the irrigation water is extremely important for the future development and increased use of irrigation water.

During 1948 the Board of Water Engineers and the Division of Irrigation cooperated with the Sedimentation Section, Soil Conservation Service and the Bexar-Medina-Atascosa Counties Water Improvement District No. 1 in making a sediment survey of Medina Reservoir. This is the third such survey completed since 1925.

Design and Construction of Equipment Needed in Irrigation Research.
(Utah) (W. C. Barrett)

Work has been continued on the development of a more efficient machine for the transportation of snow survey parties and equipment. A progress report was completed in June and construction of an improved snowmobile is about 90 percent completed. There had been little previous investigations of the nature of flotation and traction of over-snow transportation vehicles.

The factor of total weight of the snowmobile has been overcome to a limited degree. The machine built, though weighing considerably less than any now used, is heavier than it is believed a production design would require. High tensile strength steel in appropriate steel shapes and welding processes could be used to materially lighten the weight of the machine. The purpose of the type of track used in the present model is to make a machine that could go over any type of terrain, particularly to withstand sharp projections such as rocks which are dangerous to the pontoon type of machine such as the Tucker Sno-Cat. In this respect the latest machine has been completely successful. Some difficulty with the track slipping out of place has been experienced under rather unusual conditions, but it is believed that a design has been made to overcome this trouble. So far it has been impossible to get all the materials needed to fit the correct design.

SOURCES AND STORAGE OF IRRIGATION WATER

Storage of Water Underground for Irrigation. (California) (D. C. Muckel and A. T. Mitchelson)

Work was continued during the past year to recharge the underground water basins in the San Joaquin Valley. Results obtained during 1948 substantiated to a great extent the value of applying waste materials from cotton gins to the soil surface prior to water spreading. Vegetation, especially Bermuda grass, was also beneficial in promoting percolation and has the added advantage of providing a means of obtaining an income from the land. Drying periods were proven to be

beneficial. The use of auger holes backfilled with gravel showed some possibilities to obtain water penetration. Attempts to alter the quality of water artificially as to calcium and sodium content were failures on a practical basis, although it is known a hard water and a low sodium percentage are desirable.

During 1948 a new Research and Marketing project was started to work on additional aspects of the problem. A soil science and microbiological laboratory was developed and preliminary work on soil characteristics and soil microorganisms were started. A machine for obtaining undisturbed soil cores was purchased and tests with it were made. The field test ponds originally in use are being employed as a basis for the laboratory studies. Work was also undertaken to determine the possibility of underground water recharge directly from some of the North Kern District canals. The cooperation of this new project with the work already under way promises to make a notable contribution to the ground water recharge study.

DRAINAGE OF IRRIGATED LANDS

Imperial Valley Drainage Investigations. (California) (George B. Bradshaw, W. S. Donnan, V. S. Aronovici, W. T. Gish, and H. F. Blaney)

This cooperative investigation has established criteria for investigating drainage problems in the Imperial Valley, California. The Research has initiated drainage studies and developed tools and methods of approach which are being used successfully in the Operations Farm Planning program for that area. The project is conducted in cooperation with the Imperial Irrigation District and the Operations Division of the Soil Conservation Service.

During the calendar year 1948 the Research activities have been projected along two broad phases: (1) Continued refinement of tools and techniques for farm planning purposes; (2) valley-wide field investigations of irrigation and drainage which affect the conservation of soil and water resources of the valley.

Refinements have been made in curves and charts used for estimating coefficients of permeability. A new type of falling head permeameter has been devised and tested. Tile system designs are being analyzed for their adequacy and efficiency. Leaching studies on tiled areas are in progress.

In the valley-wide phases of the program, work continues on evaporation studies on Salton Sea, the only outlet for drainage wastes. Water-table fluctuations are being charted and seepage studies undertaken on the undeveloped 200,000-acre East Mesa. Soil sampling and recording of irrigation data on the East Mesa Experimental Farms have been

started. Reconnaissance work was begun on the 62,000-acre West Mesa. The irrigation and drainage problems of these two adjacent areas are vital factors in the over-all drainage problem of the lower level Imperial Valley area. A comprehensive survey of the artesian basin in the eastern part of the valley has been made.

San Fernando Valley Drainage Investigations. (California) (W. W. Donnan, V. S. Aronovici, G. M. Litz, and H. F. Blaney)

The drainage studies in San Fernando Valley are being carried on in cooperation with the San Fernando Valley Soil Conservation District and the City of Los Angeles. The objective is to determine the cause of the high water table and to obtain basic data for the design of remedial measures. The work during 1948 has been aimed at locating where the water table problem actually occurs. This has been accomplished by the installation of a large number of piezometers. A second phase of the work has been to interpret the effects of rainfall, irrigation, pumping and leakage from wells on this water table. Leaking wells have been located, other leakage has been detected, unit values of rainfall penetration have been calculated, and a survey started of crop acres and irrigation waters applied. Soils investigations have progressed along with the engineering phases of the study through assistance of V. S. Aronovici. Soil cores have been analyzed in the laboratory at Pomona for coefficient of permeability, volume weight and mechanical analysis. Tools and techniques have been devised which have assisted with the research work in San Fernando Valley and have found application in other irrigated areas.

IRRIGATION INSTITUTIONS

Adaptability of Irrigation Enterprise Organization to Future Development. (California) (W. A. Hutchins)

During 1948 the progress report of the study was completed, mimeographed, and transmitted to the two cooperating agencies.

Members of the staff of the Bureau of Agricultural Economics conducted the field work, and Hutchins prepared the largest part of the report. H. E. Selby and Stanley W. Voelker, BAE, assisted in preparing the report and are listed as co-authors. The three authors are in agreement upon the report as a whole and on all essential details.

The progress report has not been prepared with a view to publication. The object of the report is to bring together the results of the study for use within the Department. Later, when other commitments permit, it is planned to prepare a bulletin for publication by the Department.

The report contains 182 pages (mimeographed), in four parts:

I. Purpose and scope of study. This relates the importance of irrigation organizations, purpose of the study, terminology, types of organizations, and organizations selected for the study.

II. Characteristics of selected irrigation enterprises of various types. This relates, for the enterprises within the type-groups, their purposes of organizing, agriculture, water supply, water service, capital, revenue, and management.

III. Success or failure of irrigation enterprises. This relates the meaning of success or failure, factors influencing financial success or failure, relation of type of organization to success or failure, and factors related to the value of irrigation water. It is brought out that the significant point in determining financial success or failure is the cost of the water to the users in relation to the amount of benefits obtained from the water. It is further brought out that the success or failure of an irrigation enterprise appears to depend primarily on factors other than mere type of organization, but that the type of organization may have an important relation to the degree of success or failure because of relative advantages and disadvantages of the various types under various circumstances.

IV. Advantages and disadvantages of types of irrigation organizations. This relates the advantages and disadvantages of the several types in some detail in relation to organizational procedure, financing, revenue, allocations of water privileges, inclusion of land in projects, exclusion of land from projects, exemptions from taxation, and attitude of the water users. Minor topics are covered in less detail. Also included is a discussion of the probable results if the enterprises studied had been under some other type of organization.

The report includes a comprehensive summary and conclusions, set up by topics, and a list of the organizations included in the study.

MECHANICS OF EROSION UNDER IRRIGATION

A Study of the Irrigation and Soil Loss Characteristics of Contour and Down Slope Irrigation. (Washington) (Stephen J. Mech)

Experimentation in 1948 continued in the same manner and on the same plots as that in previous years. The alfalfa was permitted to grow until the end of May when a little over two tons per acre of dry matter was plowed under. Late potatoes were planted the middle of June. Their irrigation and erosion characteristics were studied at three moisture levels and three different stream sizes.

This year was the first of the scheduled three years of row crop in the rotation. Information was obtained not only on the irrigation of potatoes but also on the other changes that the plowing under of established alfalfa involves. We now have information on the first year of the "soil-depleting" phase of the rotation. The value of this information is enhanced because of the previous years of data and will be further increased by subsequent tests on sugar beets and corn.

Irrigation of potatoes was based not on the calendar but on the soil moisture content of the soil as determined by soil moisture samples. One set of plots was kept "wet" with the available soil moisture ranging from field capacity to a minimum of 75 percent. The medium plots ranged from 60 - 100 percent and the dry from 35 - 100 percent. During the season the above soil moisture ranges were maintained by 8, 4 and 2 irrigations respectively. This is in addition to a uniform irrigation just before planting.

There was only a small difference in yield between the different irrigation treatments. This, however, was complicated by the presence of fusarium wilt which may have been a considerable factor in limiting yield.

Irrigation and erosion characteristics were not, however, so influenced by the wilt and reflect the influence of soil moisture and treatment. One result is the wide difference between the infiltration on the "dry" plots and those on the "wet" plots. The magnitude of this difference persists even after the dry plots have been irrigated for ten hours or more. Another is the large amount of soil that is moved by the irrigation water even though the organic matter of the plots was just about at its peak for row crop conditions. This points to the limited influence of organic matter as an erosion control measure under irrigation.

Tabulations of irrigation application, runoff, erosion, infiltration, and stream velocity, as well as erosion and soil moisture distribution are being made. These results are being reported in the routine monthly reports to the Chief of Research as they become available.

SNOW SURVEYS

The results of the snow surveys have continued to be employed not only by irrigation companies but also by western banks, railroads, municipalities, State and Federal research organizations, public and private hydroelectric power plants, manufacturers, agricultural seed companies, newspapers and press associations, and a large number of farmers and businessmen in local communities. With the continued demand for this type of information the reports of each of our project

workers in this field showed an increased difficulty in obtaining adequate support so as to have both technical assistance and clerical help that is urgently needed to carry on this important service. The shortages in the technical staff are preventing the development of an adequate system of correlation between rainfall, snowfall, ground moisture and streamflow observations in the manner that had been planned for this phase of the work. Even though some expansion of the budget was possible during the past year it has not been sufficient to keep up with the increased demand for information and added service to the western irrigated communities.

In 1948 approximately 1,000 snow courses were again surveyed partly on a monthly basis starting in January, while all courses were measured on April 1. The following water supply forecasts were again issued:

1. Missouri and Arkansas Drainage Basins
2. Rio Grande Drainage Basin
3. Colorado River Drainage Basin
4. Columbia Drainage Basin
5. Montana Cooperative Snow Surveys and Forecasts
6. Utah Cooperative Snow Surveys and Forecasts
7. Oregon Cooperative Snow Surveys and Forecasts
8. Arizona Cooperative Snow Surveys and Forecasts
9. Nevada Cooperative Snow Surveys and Forecasts

With the increased interest and constantly widening use that is being made of this type of information, this is one phase of our irrigation program which should be notably expanded in order to give adequate service to the irrigators in the western states.