

Soil Drifting on Cropland In the Plains Area of Montana

By

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With

Soil, Insects and Land Use Supplements

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Foreword

Many in the Great Plains area now realize that control of soil drifting is a complex problem involving many direct and indirect factors. This publication is an effort to classify some of the responsible factors, as well as to outline the more successful methods of control. No claim is made to originality in the material presented. It is simply a compilation of information gathered from farmers, Experiment stations, the Soil Conservation service, and other sources.

Naturally, the material presented is of a general nature and may need adaptation for local application. For further information to fit local conditions, see the county extension agent.

Soil drifting is not new in Montana. Many soils in fact, originated as wind-borne deposits, laid down over a period of thousands and millions of years. Such soil movement is classified as geologic erosion and generally speaking, proceeds at a very slow rate, imperceptible during one generation. This publication is not concerned with this type of erosion.

What is of concern, and what is relatively new, is the severe dust storm that clips growing crops, banks fences with dirt and, most serious of all, removes soil to parts unknown. This type of damage has been increasing for the last quarter century, and must be conquered to insure a permanent agriculture in the plains area.

Serious drifting on crop land probably started in Montana about 1915. From this start, it has spread until now there is but little crop land in the plains area that at some time or other has not undergone soil drifting. Nor does any soil type appear to be free from such damage, although the very heavy and light soils seem to be most easily affected. It is safe to say, however, that no soil is immune to drifting under certain conditions. Adequate precautions are necessary on all soils.

One of the reasons why precautions are not observed more frequently is that soil drifting ordinarily occurs spasmodically, rather than every year. Many operators are inclined to consider drifting an abnormal condition, which nature will correct without any change in farming practices. On the other hand, entire communities, such as the "Big Flat" in Blaine county and the Square Butte area in Chouteau county, have adopted practices that have controlled drifting, even during the recent period of drought and high winds. Such practices are regular operations used every year.

To demonstrate conservation practices on a community basis, the Soil Conservation service established the Power-Dutton demonstration area in Cascade and Teton counties in 1935 and the Culbertson area in Roosevelt county in 1936.

Additional individual demonstration farms, employing practices applicable under local conditions, are now found in 18 counties of the state.

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Causes of Soil Drifting

The apparent, immediate cause of drifting is the action of wind on soils which are in a condition to be transported by wind action. The wind velocity necessary to cause drifting varies with conditions, but bare soil, when it is loose and dry, may begin moving with wind velocities of from 12 to 15 miles per hour. This being the case, it is obvious that drifting is most general during drought years. Some soils, however, are affected less by drought than are others. In general, sandy soils, in which it is impossible to obtain a cloddy condition, tend to drift whenever they become dry. Other soils, where a cloddy condition exists, will not move readily, even during periods of drought and high winds. The problem with such soils is to retain that cloddy condition during dry periods.

When some of the heavier soils are summerfallowed or fall plowed they tend to disintegrate during alternate periods of freezing and thawing even though they go into the winter in a cloddy condition. To a lesser extent, this is true of all soils, but it is most noticeable in the heavy soils, making them particularly subject to blowing in late winter and early spring.

Experience and observation, extending from the time the plains area was first broken, indicate that the soil drifting hazard increases with cultivation. When first broken out, the fibrous material of the original vegetation is an effective aid in holding the soil particles together. With continued cultivation, however, this soddy condition is lost, and soil drifting becomes increasingly greater.

Soil structure also is modified by cultivation, in that the aggregates rapidly become smaller after the sod is broken, resulting in an increased hazard. As these soil aggregates are made finer and finer, they become more and more difficult to hold in place.

It has been observed repeatedly that drifting is especially likely to occur during periods of alternating showers and high temperatures. Soil that has dried after a rain seems to be in ideal condition to take off with the wind, unless it is reworked with some adapted tillage implement. This erosion tendency appears to be particularly true of the lighter soils.

Though both sandy and extremely heavy soils have been observed to drift most easily, this vulnerability appears to be caused by their condition rather than by their texture. Such soils are difficult to maintain in a rough, cloddy condition that resists wind action. Preliminary evidence indicates that when they are in a smooth, pulverized condition, one soil will drift as quickly as another.

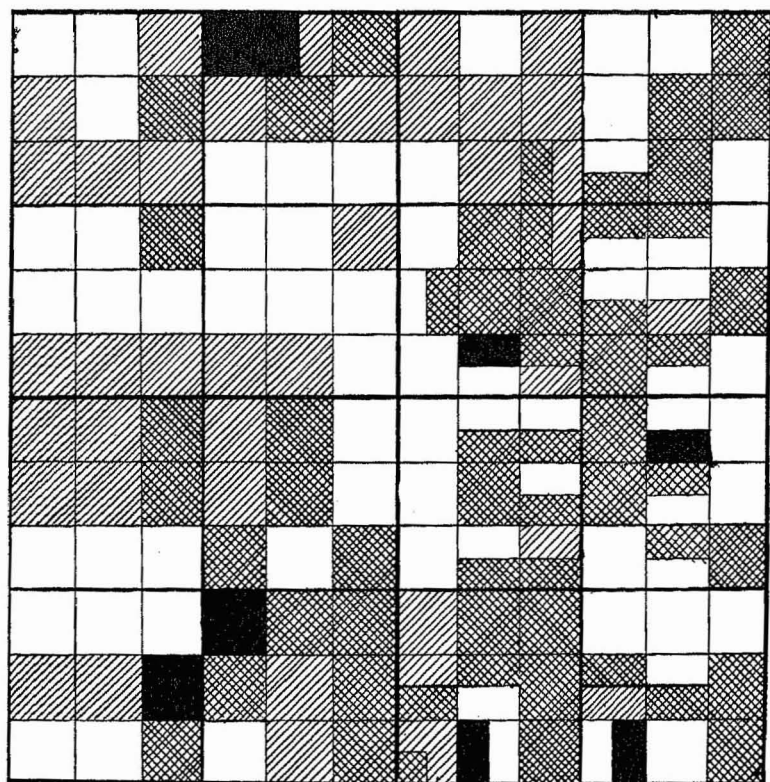
One of the most common immediate causes of drifting is the existence of vulnerable spots in many fields. These may be ridges or knolls, or places where light or easily eroded soil exists. Such spots start drifting, and the soil movement spreads to other parts of the field that would have remained in place had not the drifting begun at some vulnerable point. This wind erosion spreading habit holds true not only for a field, but for entire communities, where one "blow" field may start the entire area moving. This fact points to the need of community as well as individual action in erosion control, especially where a large percentage of the area is made up of crop land.

Damage By Soil Drifting

No accurate method has been evolved for estimating the damage caused by soil drifting. Such damage involves a variety of factors and varies with the type of soil. Nor are there accurate data showing the acreage affected and the amount of soil removed.

A survey made by the Montana Agricultural Experiment station in 1936, showing the extent of erosion in a portion of the Judith Basin is shown in figure 1. Other areas of the state show similar soil removal, although some are less and some more severely affected. Generally speaking, soil drifting has occurred over the greater part of the crop land of the plains area.

EROSION RECONNAISSANCE OF T 14 N R 16 E



DEGREE OF SOIL DRIFTING

Fig. 1. A map showing intensity and distribution of erosion. From information compiled by the Agronomy Department of Montana Agricultural Experiment Station cooperating with the AAA.

The amount of plant nutrients varies in different soils, but a fair average for Scobey Loam, which is a fairly typical dryland soil, would be approximately 0.10 per cent nitrogen and 0.07 per cent phosphorus. These are the two plant nutrients in which

Montana soils are most likely to be deficient. The removal of 1 inch of soil per acre represents the loss of approximately 230 pounds of phosphorus and 330 pounds of nitrogen. The loss of phosphorus is much more serious than the nitrogen waste because nitrogen tends to be replaced fairly rapidly by natural processes. Phosphorus however, must be restored by the addition of phosphorus-bearing fertilizer—an expensive process. Furthermore, supplies of phosphate are more limited than those of the other common plant nutrients. The 230 pounds of phosphorus lost is sufficient to produce approximately 880 bushels of wheat, which, even in our heaviest producing areas, represents a good many wheat crops. These figures indicate that Montana soils are amply fertile for almost an indefinite period, but point out clearly the losses when erosion occurs.

The effect of soil drifting on crop yields varies greatly with the soil type. In many areas of the state, on relatively shallow soils, large acreages have been ruined for profitable crop production. The effects are particularly severe where the subsoil consists principally of sands or gravels. In the case of many of the sandy soils, the subsoil is even more erosive than the top soil, further adding to the drifting hazards when the topsoil is removed. Considerable areas of such soils are to be found in the Judith Basin, on some of the benchlands along the lower Yellowstone, in northeastern Valley and western Daniels counties, and in the "Big Flat" in Blaine county.

Where gravel or sand subsoils exist, every inch of topsoil removed greatly lessens the water holding capacity of such soils, making crops grown thereon more easily affected by drought as well as less responsive to summerfallow. Experiments conducted over a period of years at Mandan, North Dakota, by the United States Department of Agriculture showed that storing an additional inch of moisture in the soil resulted in an increase of 6.6 bushels of spring wheat per acre. This again emphasizes that moisture is the limiting factor in crop production in the plains area, where seasonal rainfall often is deficient and soil moisture reserves play an important part in crop yields. To stay in profitable wheat production, it is imperative that soils

be guarded against any loss in rate of moisture infiltration and against loss in moisture retention or holding capacity.

When drifting occurs in sandy soils, the silt and clay fractions, humus, and other organic matter move most readily. This means that with each dust storm the remaining soil contains a larger and larger percentage of sand, resulting in a loss of fertility and water holding capacity, and finally in an approach to actual dune sand conditions under which stabilization is extremely difficult.

In the sandy soils it is the silt and clay fraction, and the humus and other organic matter, that give both fertility and moisture holding capacity. Dune sand has virtually no fertility and very little moisture retaining capacity. The nearer soils approach this condition, the closer we are to totally unproductive soil.

Some of the deeper, heavier soils of the state that have suffered from considerable drifting are still producing good crops during years of adequate rainfall. However, a factor that often is unnoticed enters into crop yields under such conditions. In their virgin condition, such soils have a relatively light topsoil that contains the largest percentage of organic matter. This layer has a high rate of infiltration, allowing water to be held even during periods of rapid precipitation. This rapid rate of infiltration results in the water being held until the heavier layer below has time to absorb and hold the water where it will be available for plant use.

Once this top layer is removed, the situation changes. The rate of infiltration is considerably decreased, resulting in increased run-off and erosion by water, as well as in a smaller percentage of the total precipitation being stored in the soil for crop use. Further, the water is held near the surface where evaporation is most rapid. In addition to the effect on moisture penetration and retention, loss of the topsoil results in a condition under which it is difficult to get the soil into a proper state of tilth. Not only is more power required to operate the implements, but puddling, crusting, and excessive packing of the soil are more likely to result. When fallowed, such soil is subject to

drifting in the late winter and early spring after alternate freezing and thawing have tended to disintegrate the clods. (A full discussion of the subject will be found in the section entitled "Soils.")

Besides the damage to the soil itself, soil drifting causes untold crop losses. During the spring of 1937, approximately a million and a quarter acres of crops were ruined by soil drifting, and more than a million additional acres were injured. In addition to the crop injury, fences, roads and buildings were piled high with drifted soil; and fields contained dunes wherever any obstruction, such as weeds, appeared. These accumulations are an important source of drifting later on, because they are difficult to stabilize.

In many cases, drifting in the spring delays seeding operations, resulting in crops being more susceptible to insect injury, especially by grasshoppers, and to crop diseases, such as rust.

Dust storms certainly are not conducive to the health of either human or animal life. Even in dwellings, it is impossible to prevent the entrance of dust, which causes not only inconvenience, but injury to health in breathing the dust laden air. In some of the most severely affected areas there have been severe livestock and poultry losses from dust inhalation.

Control Measures

Control measures may be divided into two general phases: One is keeping the soil in such condition that winds will have less tendency to cause drifting. Examples of this method include the cloddy mulch and the ridged surface. The other approach is to lessen the force of the wind by the use of mechanical barriers. Examples of such treatment are strip fallow, trashy cover and field hedgerows.

The safest procedure, and one that is being followed more and more, is to use as many of these practices in combination as conditions will permit. Unfortunately, there are no means of forecasting seasonal conditions, and effective safeguards require constant vigilance. This care will, in the end, be the cheapest insurance, because drifting, once started, requires ex-



Fig. 2. A cloddy surface, free from weeds, is the aim of all summer tillage operations.

pensive emergency measures for control, if indeed it can be controlled when well under way.

Tillage: Proper tillage is without doubt the most important single feature in soil drifting control. Nor is tillage an operation that can be carried on at the same time with the same implements every year with equally successful results. Tillage methods and



Fig. 3. A once productive field ruined by soil drifting.

practices to achieve the desired ends must be changed to fit the immediate conditions. Not only do seasonal conditions vary, but soil types, kind of crop, implements available, and economic circumstances of the operator also are subject to variation.

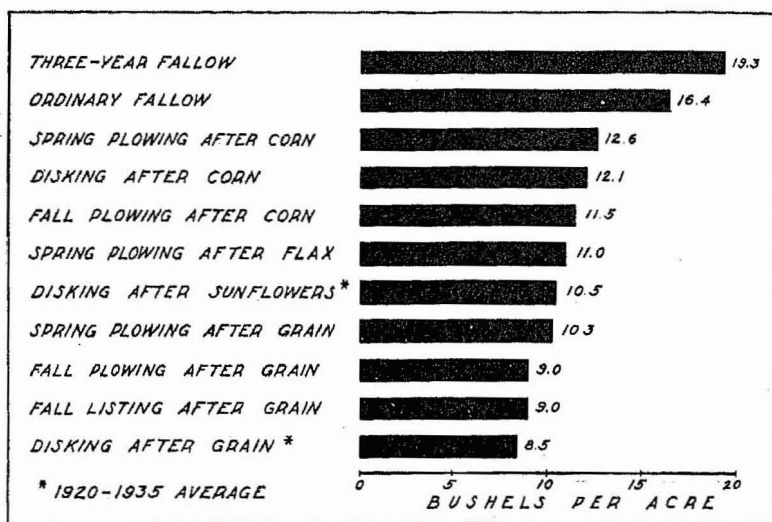


Fig. 4. Relative yields of spring wheat on different tillage methods at the Northern Montana Branch Station, 1917 to 1935.



Fig. 5. Fallow worked with a disk harrow. A smooth, pulverized surface invites soil drifting.

Summerfallow has no doubt been a contributing factor in soil drifting. This practice, however, has so many advantages that it probably will continue to be a standard practice in areas adapted to the fallow system.

Figure 4 gives the yields of spring wheat under different tillage methods at the Northern Montana Branch station, near Havre.

With this yield advantage, summerfallow, where the soils justify it, is the logical preparation for wheat, and the problem is to find ways and means of holding the soil during the fallow period. Fallow is carried on primarily to preserve moisture and to kill weeds. The stage of tillage, popular during the days of the Campbell Dry Farming System, when a dust mulch was considered indispensable for moisture preservation, is pretty well passed. Though there is nearly universal agreement that the



Fig. 6. The duckfoot cultivator, properly used, is one of the best summer tillage implements for Montana conditions.

cloddy mulch is superior, there is no one generally successful system for obtaining and retaining this cloddy mulch. There are, however, several principles which may serve as guides.

To be effective, fallowing should be done early. The exact time for the initial operation varies in different localities, and in different seasons; but experimental evidence indicates that a decrease in crop yields results unless the fallowing is completed before June 1. In some areas, farmers make it a practice to work their fallow before seeding, although the general method is to fallow after seeding operations.

The longer fallow operations are delayed, the longer is the time the stubble strips offer protection to the crop strip. In years when conditions create an extreme drifting hazard, it may be advisable not to fallow the stubble strips until the crop strip has attained sufficient growth to offer the necessary protection. In case of extreme drought when no crop is produced, this may mean failure to work the stubble for the entire year. Such a plan probably is not as unorthodox as it may appear; because during extremely dry years, fallowing

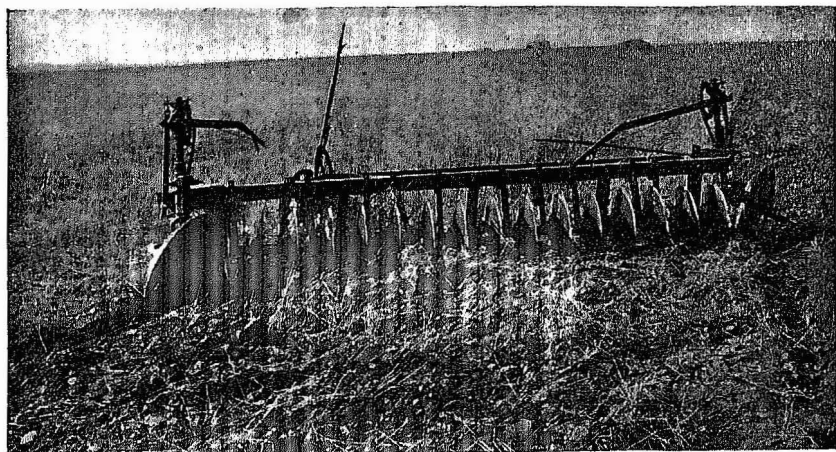


Fig. 7. Where the cover is too heavy to be handled with a duckfoot, the one-way is a very effective implement for plowless fallow.

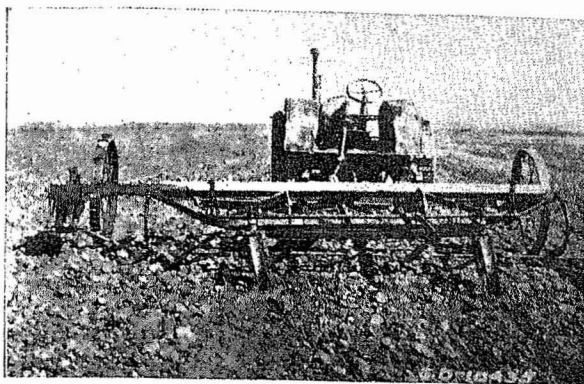


Fig. 8. The rod weeder is an ideal implement for intermediate fallow operations where the soil is not too stony. This implement leaves the clods and trash at the surface

cannot conserve moisture that is not received. Fall working in preparation for fallow the following year is not recommended, as this additional operation tends to cause drifting; and experimental results indicate that leaving the stubble undisturbed the first winter results in the largest crop yields.

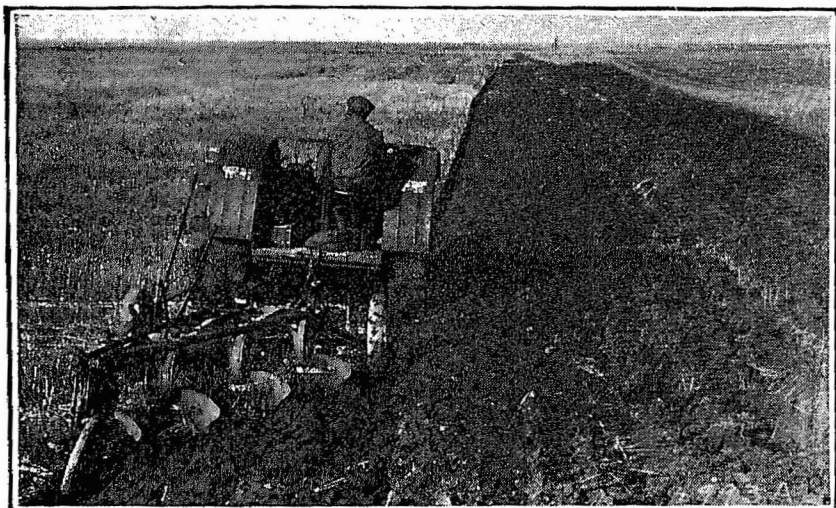


Fig. 9. Most of our soils are benefited by working at intervals with the moldboard plow. Heavy soils require plowing more frequently than do lighter soils.

The first fallow operation, whether plowed or plowless, should be the deepest. Whether a plow or cultivator is used, the initial operation should be about 6 inches deep. At the time summer fallow should be started moisture conditions are most likely to be good, and less power is required to operate at that depth than when moisture is lacking. This first operation, if moisture conditions are good, will, in most soils, bring clods to the surface. Subsequent cultivations should be to control weeds only and may be done at a shallow depth. Both the duck-foot cultivator and the rod weeder for later cultivations tend to preserve the cloddy condition. The rod weeder, where the soil is not too stony, is ideal for intermediate fallow operations. For the last operation in the fall, however, the duck-foot, equipped with wide shovels to ridge the soil, will leave the surface in better condition to withstand drifting during the winter and early spring. Unless there is an extremely heavy stubble, the one-way should not be used on fallow except for the initial operation.



Fig. 10. The duckfoot cultivator equipped with ridging shovels. These shovels are adapted to emergency soil drifting control, and may also be used for the last operation in the fall on fallow. (Photo courtesy Soil Conservation Service).

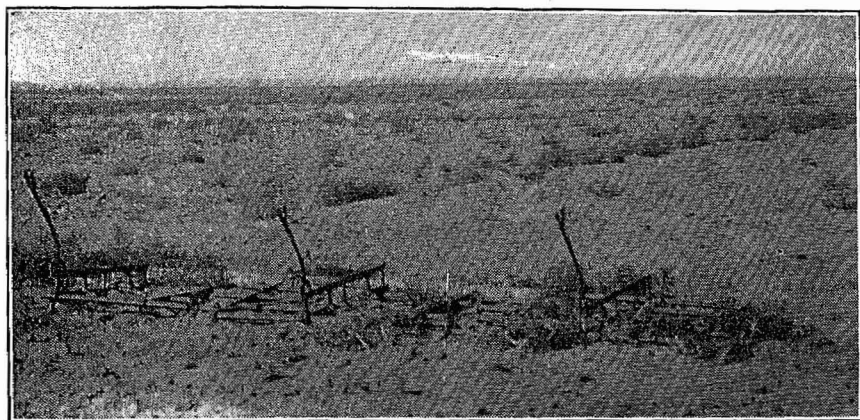


Fig. 11. An implement which has its value in humid areas, but one which is not adapted to dryland conditions.

A satisfactory rule to follow in plowless fallow is to use the duck-foot cultivator for the initial operation whenever possible, reserving the use of the one-way for those years when the

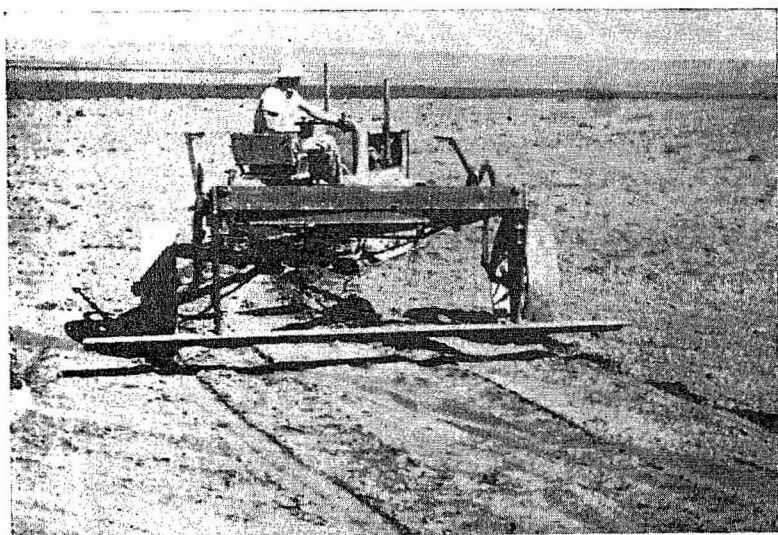


Fig. 12. The Noble weeder, a new fallow implement developed in Canada, which leaves the trash on the surface. Its construction permits penetration of the soil where the rod weeder cannot be used.

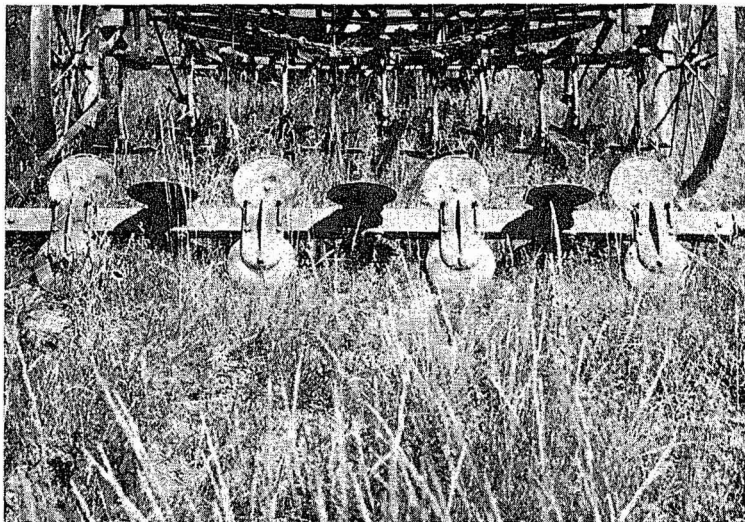


Fig.. 13. The "Waffle Machine. A new implement pulled behind the regular tillage implements to "pockmark" the land to secure greater water retention.

cover is too heavy to handle with the duck-foot. The moldboard plow may be used satisfactorily during years when little or no cover is present, because plowless fallow under such conditions is less effective than when cover can be left at the surface.

Recent work at the Swift Current Experiment Station, Swift Current, Canada, indicates the value of different tillage methods. The average amount of soil blown away from a bare surface by a fairly strong wind was reduced 61 per cent where small ridges were cultivated at right angles to the wind; by 86 per cent where straw was worked into the surface at the rate of one-half ton per acre; and by 95 per cent where both ridging and straw were used. This indicates quite clearly the value of stubble and the dangers of stubble burning. Even if worked immediately after burning, such land is much more susceptible to drifting than that on which the stubble is retained.

Although the plowless fallow method has the advantage of leaving most of the trash at the surface, this practice should not be followed exclusively on most Montana soils. From the standpoint of both soil drifting and crop yields, occasional plowing



Fig. 14. One-way converted to a basin lister. The notched disk leaves a small area in the furrow undisturbed, forming a basin.

has advantages. Heavy soils may need to be plowed after every other crop, or every 4 years under the fallow system; whereas on the lighter soils, plowing every 8 years may be sufficient. In this connection, it might be advisable to mention that no type of tillage should be attempted on dry soils. All tillage implements tend to pulverize dry soils, regardless of how carefully they are adjusted and used.

Seedbed preparation also has undergone radical changes since the first sod was turned in Montana. Instead of striving for a surface "smooth as a board," the aim now is the direct opposite. On fallow land, the usual practice now is to cultivate once with the duck-foot and to seed without any further operations. Several successful operators pull the duck-foot **behind** the drill, the object being to leave the ground in better condition to resist wind action. Still others prefer the springtooth harrow for the seedbed preparation on fallow. Implements that cannot be recommended for seedbed preparation of fallow, because of their pulverizing action, are the disk, one-way, and spiketooth harrow.

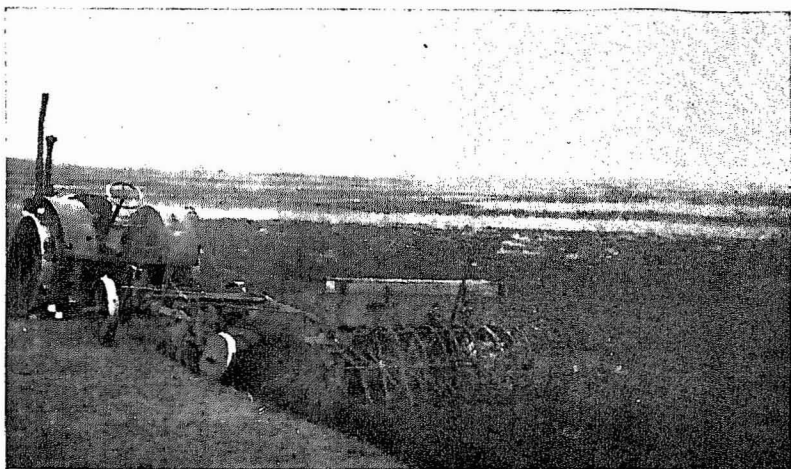


Fig. 15. A good outfit for seeding spring plowing. The press drill encourages rapid germination, thus leaving the land without cover for the minimum length of time.

For seeding stubble land, one of the best arrangements is to plow and follow immediately with the drill, preferably a press drill. This system requires the minimum length of time between turning the land over and getting the crop to the stage where it will afford protection. This method also will usually leave the ground in fairly good condition to resist wind action. In too many instances, operators are still using the disk or spiketooth harrow, or both, on spring plowing. Needless to say, this treatment leaves the ground finely divided and in no condition to withstand strong winds.

The practice of "stubbling in" spring wheat is not justified on the basis of crop yields, although such preparation usually leaves enough trash on the surface to prevent soil drifting. With winter wheat, however, this is a common practice in many areas. Under such preparation for winter wheat, the land is not so likely to drift, and the grain also is less subject to winter killing.

The furrow drill has been a popular implement for winter wheat seeding for many years, both on fallow and stubble land. The ridges left by this implement reduce soil drifting, and wheat so seeded, generally is less subject to winter killing.

During the past few years, this implement also has been used more and more for seeding spring wheat. This method not only leaves the land more resistant to wind erosion, but makes other spring operations on fallow unnecessary. Its use, however, can be recommended only on comparatively clean land, as weeds are somewhat more of a hazard when this type of drill is used.

Strip Fallow: Strip fallow is now practiced to some extent in nearly every community in the plains area of the state. Some communities have stripped their cropland 100 per cent over a period of years. Others are just starting the practice. The advantages of strip fallow include:

1. Physical protection from wind action on sheltered side reducing soil drifting hazard.
2. Soil drifting confined to one strip if soil movement starts.
3. More moisture saved in the form of snow.
4. Earlier harvesting possible many times by selecting strips. This may lessen hail and insect hazard.
5. Use of the round-end strip does away with pulverized soil on ends, which constitutes a blow hazard.

This system also has its disadvantages, some of which are:

1. Less efficient operation, because of loss of part of the implement width in finishing strips.
2. More edges to poison in case of grasshopper infestations.
3. Possible damage to crops in moving implements from strip to strip.
4. Loss of small amount of cultivated land where round-end strip is used.
5. Additional work required to handle Russian thistles on edges of strips.

The actual reduction in wind velocity on the lee side of a stubble strip is affected by the height of stubble, velocity of wind, slope of land, width of stubble strip, and perhaps other factors. According to results from Canada, an 8-inch stubble will afford protection for approximately 50 feet on the lee side.

Among the most important advantages of strip fallow is the fact that even though soil drifting may start, it usually is confined to a portion of one strip, instead of spreading over the field. Even a relatively light stubble cover in the strips is effective in stopping the spread of soil drifting.

Observation and experimental evidence both indicate that a stubble cover conserves more snow moisture than does fallow land. For this reason more moisture is held on a strip-fallowed field over a period of years than on the same field alternately cropped and block-fallowed. Even though only one-half the field is covered by stubble in strip fallow, this is usually sufficient to hold the snow that would be blown off a block fallow field.

Usually there is a difference in dates of ripening of the various strips, just as there are generally green or backward spots in block fields. By selecting strips, it is often possible to begin harvest earlier, thereby avoiding several days of hail and insect hazard.

The round-end strip is a comparatively new device in Montana. Its advantages are so obvious, however, that it is rapidly gaining in favor wherever it has been introduced. This type of strip avoids the pulverized end, which is a natural accompaniment of pulling machinery across the ends with the implements not working.

The round-end strip, and method of adoption, are shown in figure 16.

In discussing the disadvantages of strip farming, loss of efficiency is the most frequent criticism. Without doubt, there is some basis for this complaint. Most operators have found that it is almost impossible to lay out their strip widths in such a way that the full strip will be covered by a certain number of of trips using the full width of the machine. Accurate laying out of the strips and care in operation will, however, hold losses to a minimum.

Strip cropping in relation to grasshoppers and other insects is fully covered in another section and will not be further discussed here.

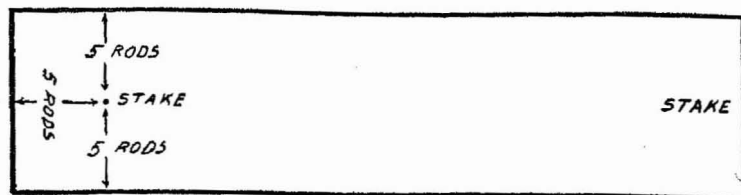
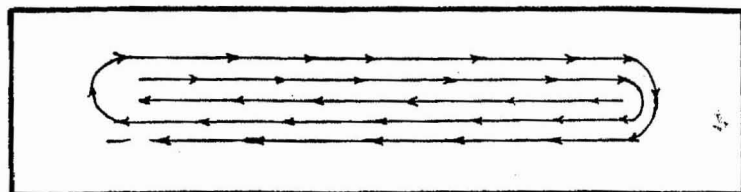
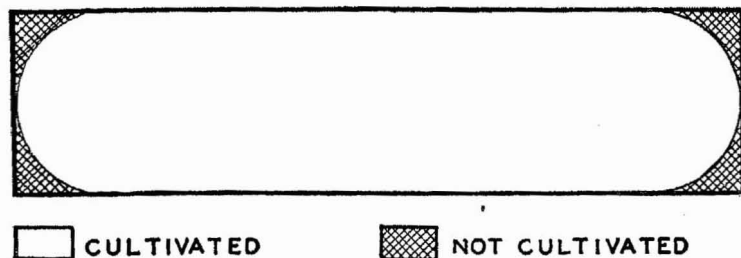
1. STAKING THE FIELD**2. STARTING THE FIELD****3. COMPLETED FIELD**

Fig. 16. (Chart courtesy Soil Conservation Service,)

Strip farming requires moving machinery from one strip to another, and, unless headlands are of adequate size to permit moving the implements, some grain will be injured when moving from strip to strip.

By using the round-end strip, a very small amount of land is not cropped. However, the convenience of this method will

more than repay the small loss of crop acreage. It is advisable to seed these small areas to grass in order to avoid an unsightly weed growth.

One of the most frequently heard criticisms of strip fallow when it was first started was that weed growth along the edge of the strip interfered with harvesting and, further, that these weeds scattered over the entire field. Most operators have overcome this difficulty by seeding a few feet into the adjoining strip and gradually working this additional seeding into fallow during the summer. A little more seed is required under this system, but it does eliminate weeds.

Width of Strip: There is no one correct, simple answer to the width of strip question. The proper width is influenced by such considerations as type of soil, slope of land, maximum wind velocities, tillage methods, temperatures, and possibly other factors. One fact is evident, however, that there is a very definite tendency to reduce the width of strips in this state. Whereas the first strips were 20 and 30 rods wide and in some cases even wider, the last few years strips have averaged nearer 10 rods. Operators who have cut down their strip widths give the following reasons: Though the wider strip was generally effective in the sense that the entire field did not drift as readily there was frequent drifting of the fallow edge removed from the protective strip. This resulted in an accumulation of drift soil in the west side of the stubble strip not only forming an unsightly ridge, but in many cases attaining sufficient size to make farming over it inconvenient. This accumulated soil was a further blow hazard because it was much more likely to move again than was the rest of the field.

On the more erodible soils, the most common width today is the 5-rod strip. Farmers in other areas, where the soil is such that a cloddy condition usually can be maintained, have adopted a wider strip, usually 10, 12, or 13½ rods. The fact that many operators have cut their 20-rod strips exactly in half and now farm in 10-rod strips, indicates that the narrower width is gaining in favor.

Some farmers start their strip fallow by double cropping one-half the field after a crop has been removed, but others prefer a more gradual shift. The following chart, worked out by the Soil Conservation service, shows a deferred system of changing from block to strip farming.

CHART SHOWING DEFERRED SYSTEM OF CHANGING FROM BLOCK TO STRIP FALLOW

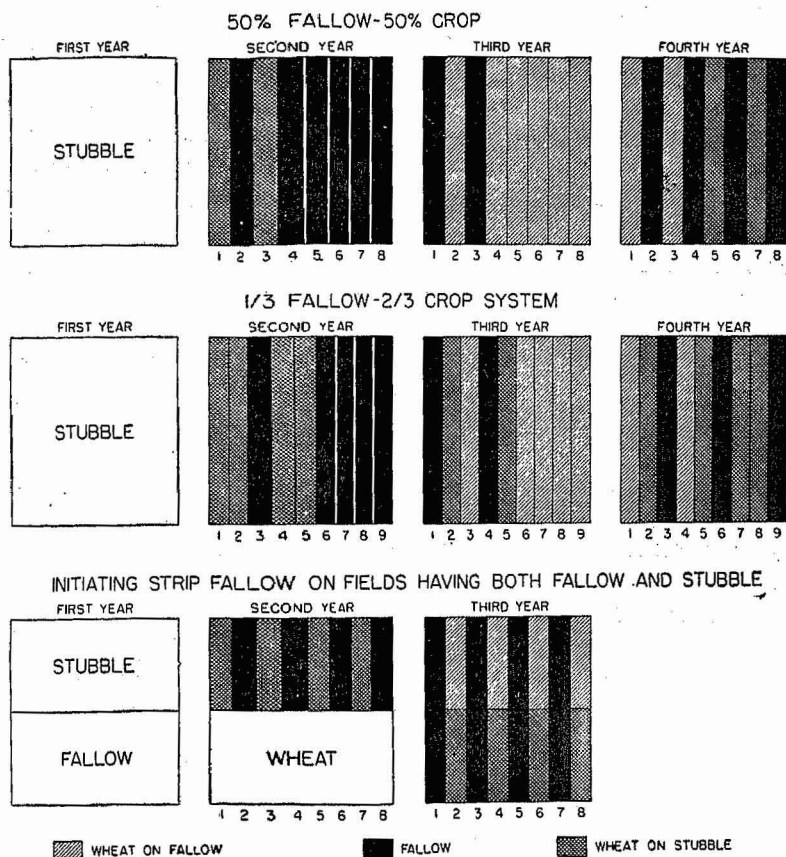


Fig. 17

Strip Cropping: In areas where fallow is not adapted, strip cropping is a successful practice in soil drifting control. There are many methods of strip cropping, only a few of which will be discussed briefly here.

Probably the most common crops grown under this system are small grains alternating with an intertilled crop such as corn in a 2-year rotation. The chief objection to this system is that as soon as the corn stubble has been seeded to grain, the grain stubble is plowed for corn. This leaves the entire field vulnerable, because the small grain has not made sufficient growth to offer protection. Where fall-sown small grains are grown on the stubble ground, a greater degree of protection is attained.

Another system that has been gaining in favor is the growing of alternate strips of grasses or legumes and cultivated crops such as small grains and corn. The grasses and legumes offer a permanent protective strip, and are especially effective if a good growth is left on the ground in the fall. In the case of crested wheatgrass, the early spring growth usually is sufficient to provide some protection by wheat seeding time. When the crop and grass strips are used in a long-time rotation, this system has the advantage of grass crops being grown on all the cultivated land some time during the rotation.

For extreme wind erosion areas, a rotation of spring wheat and winter rye, or winter wheat, where it is adapted, has been very successful. The winter rye is sown in the spring wheat stubble, and the spring wheat on spring plowed rye stubble. Alternate strips of these crops will maintain cover on part of the field at all times, and necessitates exposing only one-half the field during the period when it is plowed for spring wheat. Not too much difficulty has been experienced with rye mixtures under this system as a good job of plowing kills nearly all of the volunteer rye plants.

Buffer Strips: In some continuously cropped areas, buffer strips of crested wheatgrass are being used. These buffers usually are one-fourth the width of the crop strip, and are placed between all crop strips in the field. Not only do such buffer strips

afford protection against wind erosion, but they act as markers for the edge of the strip, and also make an excellent place to run harvesting machinery when starting to harvest the strip. Fall pasture also is provided by grass in the buffers in combination with the remaining stubble.

Contour Stripping: Contour farming is a new practice in Montana. In the Southwest, however, it has been a standard practice for many years. Briefly, contour farming is simply farming along a level line. That is, all operations are conducted crosswise to the slope, regardless of the direction this may lead. Thus every furrow, every implement mark, and every crop row becomes a miniature dam for impounding water.

When combined with strip farming, contour farming also becomes an effective wind erosion control measure. Though all contour strips cannot be put at right angles to the prevailing winds, usually there is sufficient change of direction to prevent the wind from getting a long sweep over unprotected lands.

In starting this system of farming, careful engineering and planning are required. It usually is best to obtain the assistance



Fig. 18. Contour strip farming in the Soil Conservation Service demonstration area in Roosevelt County. This system guards against both wind and water erosion. (Photo by 41st Division Aviation, Washington National Guard.)

of someone who is familiar with contour farming, because the method of laying out the fields determine in large measure the effectiveness of the system.

Although experimental evidence under Montana conditions regarding the effectiveness of contour farming is lacking, preliminary indications are that it may be adapted over a considerable area of the state.

Field Hedgerows: The prairie provinces of Canada, during recent years, developed a new idea in wind erosion control through the use of field hedgerows. During the last two years, similar plantings have been made by farmers in this state and by the Soil Conservation service in its demonstration areas.

Caragana is most commonly used in these hedgerows, as it is drought resistant, is thick growing for adequate protection, and has a tap root that does not deplete soil moisture any great distance from the row.

Such hedges catch snow during the winter months, offer protection against soil drifting and tend to lessen the damage to the growing crop from hot winds. Plantings have been made on both straight and contour strips in this state, but sufficient time has not elapsed to draw any conclusions regarding their value.

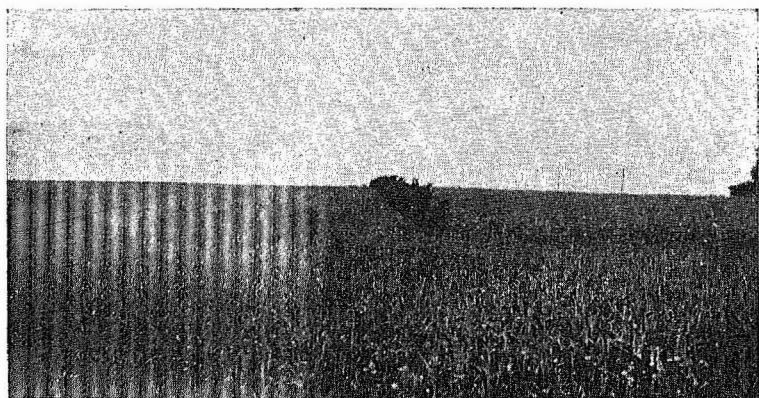


Fig. 19. Caragana field hedgerows near Regina, Canada. These protective plantings aid in wind erosion control and also tend to catch winter snows.

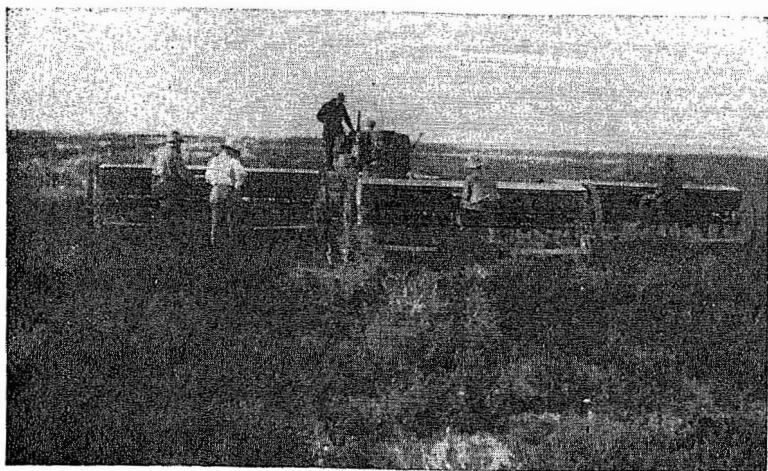


Fig. 20. Seeding crested wheatgrass on abandoned crop land. Fall seeding in stubble or weed cover without previous cultivation has given good results.

Some of the objections raised to the field hedgerow are that trees and shrubs will not grow in all parts of the state, that such hedges catch wind-blown weeds, and that, if drifting occurs, soil piles up in such plantings.

Re-grassing: There are areas in this state where there is considerable question whether the growing of cultivated crops can be continued. Such areas may include entire communities, one field, or part of a field. In some cases, it may be a knoll or light soil area in a field that is a focal point for the start of soil drifting.

From the standpoint of soil conservation, the safest procedure is to restore a grass cover to such soils. Some care must be exercised in grass plantings, because any soil drifting will make the establishment of grass difficult. The surest method of re-grassing under such conditions is to plant crested wheatgrass in either stubble or weed cover during the fall months. Seeding any time after September 15, in most parts of the state, has given good results when sown at the proper depth.

Grass should be planted from one-fourth to one-half inch deep in a firm, almost solid, seedbed. This is a difficult depth

to obtain consistently with the single or double disk drill because of irregularities of land, differences in firmness of ground, and trouble caused by the weed or stubble cover. The furrow drill, however, overcomes most of these difficulties when used for grass seedings. By putting the seed into the furrow and leaving it uncovered, the natural action of wind and water usually will result in about the right seeding depth. This is not to say that stands cannot be secured without use of the furrow drill; but, as a rule, a larger number of plants per pound of seed used results when the seed is put into a furrow.

Emergency Measures: If for any reason soil drifting starts, immediate control measures should be taken. Many times, prompt action will confine soil drifting to a small, local area; whereas negligence will permit its spread.

When drifting starts on seeded land, plowing furrows a rod or so apart often is sufficient to prevent further damage. When this method is not effective, it may be necessary to ridge the area solidly with a plow, duck-foot, or lister. Though this tillage destroys the crop on the area where drifting starts, it may save the remainder of the field. Another successful practice is to spread straw or manure on the area affected. The chief objection to this method is the length of time required to cover any appreciable area.

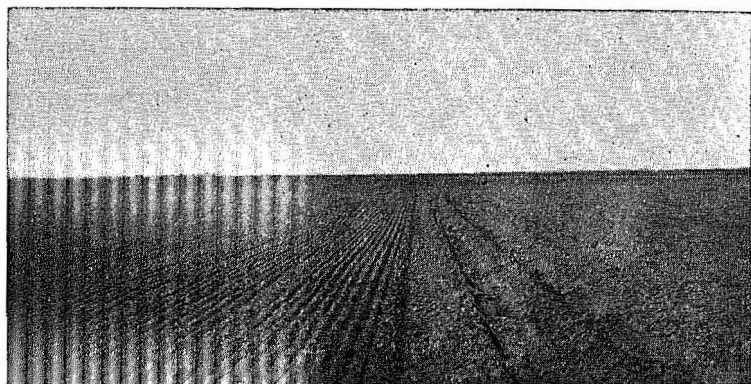


Fig. 21. Alternately listed and seeded strips. Emergency treatment where no cover existed.

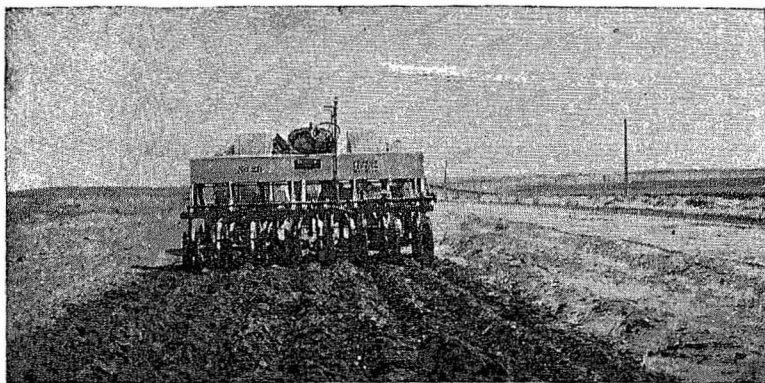


Fig. 22. Seeding drifted soil with a deep furrow drill. The ridged surface reduces the danger of soil drifting.

Where drifting has attained serious proportions over any considerable area, drastic measures are necessary. The most successful method is to ridge and furrow the land as soon as possible. This may be done with a variety of implements. Where the soil is not too hard or stony, the duckfoot equipped with ridging shovels may be used. The lister is very well adapted to this purpose. An excellent job may be done with a four-bottom plow by removing the two middle bottoms. When it is desired to seed part of the field the emergency operations may be done in strips and the intervening areas seeded. To be effective, however, the ridging and seeding should be carried on simultaneously, or the unworked strip otherwise would be a constant erosion threat.



Fig. 23. Drift soil listed and corn planted in the furrows. Cane, millet, or rye are also satisfactory cover crops.



Fig. 24. Emergency listing showing furrows nearly filled with drifted soil. Under severe conditions relisting may be necessary.

When the area is not to be seeded for harvest, solid ridging and seeding to some erosion-resisting crop is recommended. Sudan grass, sorghum, rye and millet are excellent cover crops. For late spring or early summer operations, winter rye has given good results.



Fig. 25. An excellent job of emergency control. Worked with a 4-bottom plow with the two center plows removed.

The Relation of Soil to Soil Erosion

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Soil is largely the product of the climate. Its development is influenced by a number of factors such as slope, vegetative cover, age, parent material and erosion. In the plains area of Montana the color and depth of the soil is closely associated with the elevation and longer weather record. The lighter colored and more shallow soils are usually found in the lower rainfall and higher temperature areas.

The formation of soils is a complicated process involving chemical, physical and biological actions and reactions over a long period of time. The products formed by these actions and reactions and the finer soil particles are being continuously leached from the surface soils and in areas of limited rainfall they are precipitated and filtered out at varying depths in the subsoil. This leaching and deposition gives rise to distinct soil layers or horizons which can be readily observed in a vertical soil section such as a road cut.

A normally matured upland soil in eastern Montana shows at least five horizons; namely (1) the light colored, loose laminated surface mulch, (2) the light brown to dark brown friable surface soil or zone of humus accumulation, (3) the lighter colored compact subsoil or zone of finer soil sediments, (4) the gray zone in which the soluble carbonates are precipitated, and (5) the decomposed parent material, or geologic material over which the soils have formed. Poor drainage, high soluble salt content and other factors influence the character of the horizons.

The soils of the plains vary greatly in maturity and often the above horizons are poorly developed or absent. Over most of the area the stratified parent material lies within 1 to 3 feet of the surface thus showing that the normal leaching and deposition of material is confined largely to the surface few feet of soil under native grass conditions. The color, depth, physical and chemical properties, and sequence of horizons, are the means of identifying and classifying soils from which deductions are made regarding the soil's potential possibilities.

Under normal conditions soils reach a stage in their development which is in balance or equilibrium with the physical forces. That is, the rate of soil formation and rate of losses from the surface by erosion, is approximately the same. The slow removal of the surface soil by wind, water and other agents is a natural and beneficial process, otherwise the continual leaching of the surface layers would produce an inert skeleton soil, which would be too low in available nutrients for plant growth. Excessive erosion, by either wind or water, upsets this balance and has a detrimental effect upon the physical properties of the soil and on crop production.

The surface soils are the medium through which the moisture penetrates the soil and the amount of moisture retained will depend largely upon their porosity and friability. Most of the available plant food also occurs in the surface soils. In most sections of **eastern Montana** the depth of the surface soils ranges between 3 and 8 inches and often the claypan lies within plow depth. Heavy soils low in lime are not under cultivation above the ditch. These soils have a high water holding capacity and increase in volume on becoming wet. These physical properties favor greater runoff, greater evaporation from the surface, and retard the movement of water into the subsoil. The loss of the surface soil by erosion results in the claypan lying nearer the surface and when incorporated with the surface soils produces the same undesirable features as in a heavy soil. The loss of the surface soil therefore, not only decreases the soil fertility but also decreases the effectiveness of the seasonal rainfall, thus requiring a greater rainfall for the production of normal crop yields.

Soil erosion has become increasingly more difficult to control in the older cropped sections of eastern Montana. It has been sufficiently serious in some sections to influence the use and productiveness of the land but in the better farm districts its most noticeable effect is on soil tilth. More tillage is required to maintain the soil in a good friable condition. Moisture is still the most important factor in the production of crops in the plains of eastern Montana but the continued loss of the surface soil by soil drifting will ultimately affect the soil fertility and the productiveness of the land.

The accompanying profile sketches show the range or maturity of several upland residual soils in eastern Montana together with a brief description. Also a profile of a mature developed soil on a high table land with a protective covering of Tertiary sand and gravel. The depth of the surface soils should be carefully noted.

Profile No. 1

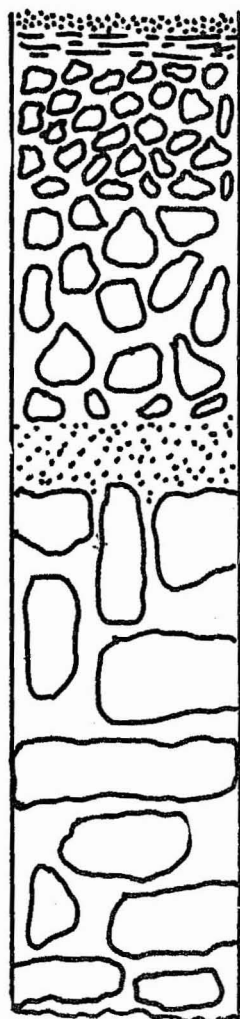
Profile No. 1 represents an immature soil such as found in the more eroding sections and in the lower rainfall areas of the plains of eastern Montana. These soils are characterized by a shallow, light, grayish-brown, laminated surface mulch, occasionally having a platy structure in the lower part. The surface soils, effervescing freely with acid are structureless, light grayish-brown and average between 3 and 5 inches thick. The subsoils grading into shales and sandstones at 2 to 3 feet are chiefly sands, silts and clays having the color, structure and stratification of the parent material.

Soils with this character of profile include such soil series as the Bainville, developed over calcareous or limey, sandy shales, the Flasher over coarse grained calcareous sandstones and the Pierre over dark colored noncalcareous shales. Soils of these series are not under cultivation and are utilized for the grazing of livestock. The fine sandy loams of the Jordan series developed over fine-grained calcareous sandstones, cover large areas of marginal farm land in east central Montana. These soils with deep, yellowish colored, fine, sandy subsoils were placed under cultivation but in most sections of the area they constitute a large portion of the abandoned farm lands. The soils of the Bridgeport series, developed over wash on the slopes of the valleys and below sandstone escarpments, or steep breaks, are deep soils and are under cultivation where the land receives the runoff from the higher levels. The immature soils under cultivation are friable and drift readily without a protective vegetative cover. The yields of crops in general average low.

Mulch—

Surface soil—Shallow surface contains major portion of fertility. Clod forming ability fair to poor. Receives moisture readily.

Subsoil—Subsoil of low organic content. Frequently sandy, occasionally very clayey. Clods form difficultly and "slake" quickly. Relatively unproductive.



Parent material—Unconsolidated parent material (such as shales or sandstones) often close to surface. Gray or yellowish color.

Fig. 26
Profile No. 1.

Best part of this soil confined to shallow surface.

Subsoil fertility less available. Little organic matter. Clayey subsoils have slow moisture infiltration. Sandy subsoils have limited moisture storage.

If exposed, subsoil is relatively barren for a long span of years. Drifts readily.

Profitable crops only in best years.

Profile No. 2

Profile No. 2 represents a mature soil such as found on the broader divides and on the rolling glaciated plains. These soils have the regional dust mulch which often has a platy structure in the lower part. The surface soils are dark brown have a prismatic structure and range from 5 to 8 inches thick. The lighter colored claypan is prismatic and usually is not as compact and as heavy as in the more mature very dark brown soil group, confined largely to the high plateaus about the mountains. The gray carbonate zone is compact and lies 8 to 15 inches below the surface. The lower depths below 20 to 30 inches, often have the stratification and structure of the parent material.

Soils with mature profiles in the uplands of eastern Montana include such soils as the Morton, developed over calcareous shales and sandstones; Scobey over drift and the Winifred over noncalcareous shales. The soils of the Joplin series in north central Montana are somewhat less mature than those of the Scobey series. The more level agricultural phases of the Morton, Scobey and Joplin are under cultivation and are devoted largely to the production of spring wheat. The heavy soils of the Winifred series are not under cultivation. The surface soils of these soil series are comparatively shallow and the loss of several inches from the surface would place the claypan within plow depth.

Mulch—

Surface soil—Surface soil friable and cloddy. Permits ready entrance of moisture. Good organic content.

Subsoil—Subsoil has less organic matter and poorer tilth. However it is cloddy, has no claypans or other impervious layers. Fairly porous. Moisture storage capacity fair.

Parent Material—

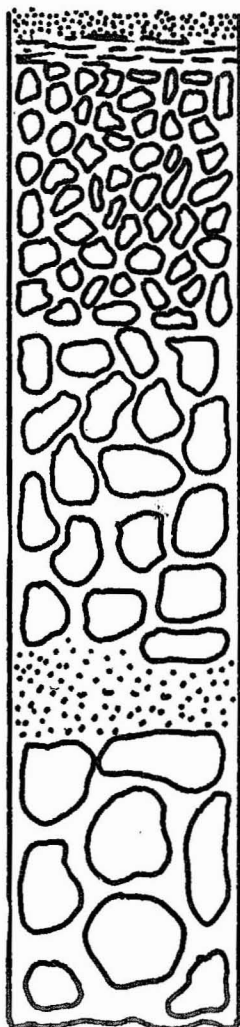


Fig. 27
Profile No. 2.

Productive, easily managed soil. Most productive if surface soil is kept in place.

When drifting exposes subsoil, yields suffer for a time because moisture storage facilities have been weakened.

Profile No. 3

Profile No. 3 represents a mature soil developed over parent material high in soluble salts. The soils of the Phillips series covering large areas in the glaciated plains of north central Montana are typical of this group. The Phillips soil areas are characterized by numerous bare spots or blow out holes depressed 4 to 6 inches below the surface. The profile of the grassed-over portion of these soils differs chiefly from that of the Scobey soils in having a deeper surface mulch and the claypans have developed into a prismatic, nutty-structured hardpan. The gray carbonate zone lies 8 to 12 inches below the surface and grades into heavy drift, often having zones of soluble salt accumulation. The surface of the bare spots is a glazed crust, underlaid with a shallow honey-combed, structured layer. The hardpans consist of hard cubical clods. The carbonate zone lies at about the same depth as in the grassed over section and grades into similar parent drift. The soils are too refractory for farming and are used for the grazing of livestock. The higher terraces along the streams are often underlaid in southeastern Montana with hardpans and when the surface soils are removed by erosion the land is abandoned even under irrigation. A wide range in the development of these soils occurs in eastern Montana.

Mulch—

Surface Soil—Friable, cloddy, surface soil. Permits ready entrance of moisture.

Subsoil—Subsoil commonly known as claypan. Contains still clays. Has poor tilth when wet or dry. Relatively impervious to moisture.

Lower subsoil—Lower subsoil of variable nature.

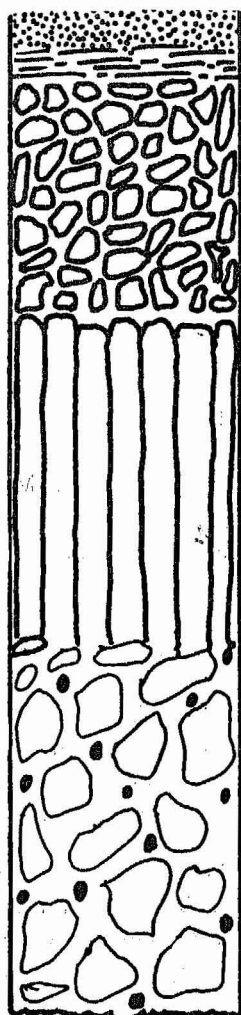


Fig. 28
Profile No. 3.

Relatively productive only when surface soil is kept in place.

If the surface soil is lost the claypan is exposed and it is not conducive to productivity.

Questionable whether this soil if eroded to claypan, can regain original productivity within a generation. Productive when intact.

Profile No. 4

Profile No. 4 represents a mature very dark brown soil developed on a tableland with a protective covering of sand and gravel in eastern Montana. The surface few inches of these soils, such as the Daniels sandy loams, are loose sandy mulches. The surface soils are very dark brown structureless sandy loams 8 to 10 inches thick and underlaid with compact reddish-brown sands. The gray carbonate zone lies 15 to 20 inches or more below the surface and grades into loose stratified sands and gravels. These sandy loams have a low average crop producing capacity. They drift readily and are difficult to keep in place after the root fiber has been destroyed. The more incoherent sands, with carbonate zones 24 to 30 inches below the surface, are not under cultivation.

The sandy loams of the Cheyenne series developed on glacial stream terraces and the less mature sandy loams of the Beaverton series developed on benchlands, have similar soil profiles and crop adaptations. These sandy loams drift under cultivation.

Surface soil—Surface sandy. Friable with clods difficultly formed and easily powdered. Organic content fair to poor. Major portion of fertility contained in this layer.

Subsoil—Subsurface sandy with low organic content, little silt or clay. Virtually impossible to form clods. Loose condition.

Lower subsoil—Loose sands and gravels.

Soils with this profile receive water readily. Under optimum moisture conditions they are productive. Are incapable of storing much moisture, consequently are relatively susceptible to drought. Are subject to drifting because a cloddy condition is difficult to maintain.

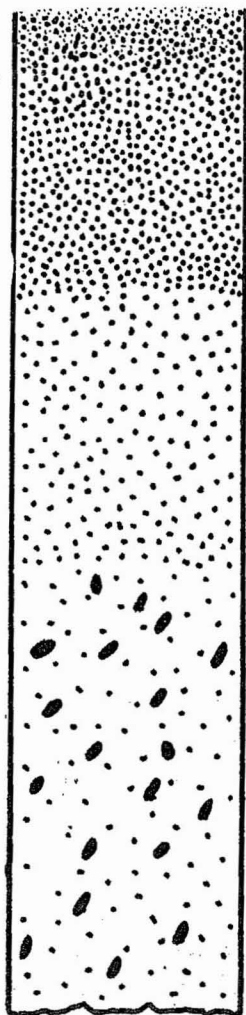


Fig. 29
Profile No. 4.

When subsoil is exposed, grass is the only safe crop.

These soils require careful management to maintain their productivity.

Subsoils are characteristically sandy with little silt or clay evident. Low fertility and an extreme erosion hazard.

Insects in Relation to Soil Conservation

By

HARLOW B. MILLS

State Entomologist

Some of the recommendations for insect control have a definite bearing on wind erosion of the soil, and, where grasshoppers, Say's grain bugs, etc., occur in injurious numbers in areas where soil drifting is a factor, the control of either the insects or wind erosion should not be undertaken without a thorough consideration of all of the factors involved.

Periodically, throughout the western states, grasshoppers develop in large numbers and in themselves may be contributing factors in soil drifting by reducing the vegetative cover and exposing the soil surface to the action of the wind. Control campaigns against these insects are built primarily on the destruction of the 'hoppers by the use of poison baits. Proper use of baits will effectively reduce 'hopper populations to a minimum. This minimum is dependent on several factors, such as the intensity of the infestation, migration of 'hoppers from nearby infested idle, reverting, or rangelands, and mass flights from distant points.

Where the infestations are local and small, the distribution of poison bait may be sufficient to reduce 'hopper populations to a non-injurious size. However, when widespread infestations of considerable magnitude occur, as has been the case for several years now, all possible means of control must be brought into play.

For some time it has been recognized that certain types of tillage assist in the control of grasshoppers. Where a sufficient number of eggs have been laid to indicate that injury may be expected the following year, as many of these eggs as feasible should be destroyed by plowing.

To be effective, plowing should be at least 5 inches deep, and the furrow completely turned over. Either fall or spring plowing will work. This practice is not effective in sandy soils or in soils so dry they form large clods when plowed. Best control is secured by plowing when the soil is moist and following immediately with a press drill.

Present information indicates that the use of a duckfoot or a one-way for destroying grasshopper eggs will not justify the cost of the operation. Stubbling in is no better than using a one-way or duckfoot.

Clean fallow which supported very little vegetation the previous summer will be comparatively free of grasshopper eggs. They are most likely to be found in weedy, fallowed and abandoned land, weedy spots in the range, stubble and for some species, roadsides, fence rows, and ditch banks. Montana's most important crop-eating species, the lesser migratory locust, commonly lays its eggs in stubble, weedy, idle and fallow lands, and weedy range. It does not concentrate its eggs along fence rows or where a good stand of grain exists.

Young 'hoppers stay close to where they are hatched for some time, provided that there is sufficient food and shade. If conditions are not agreeable they will migrate. A strip of bare soil will retard this movement, and may be employed to keep little hoppers temporarily from invading crops.

Strip Fallow and Hopper Control. Where strip fallow is infested with grasshopper eggs, it will be advisable to leave a bare strip at least 8 feet wide between the stubble and crop strip. This will temporarily stop invasion of hatching 'hoppers from the stubble strip to the crop strip.

When working the stubble strip, work from the outside toward the center, and leave a narrow strip in the middle of the stubble undisturbed. This will not necessarily kill the little hoppers, but will temporarily keep them out of the crops and concentrate them on the unworked strip, where they can be poisoned with a minimum of effort and bait.

Stripping with Buffer Strips. Where buffer strips of stubble or grass are used, and such strips will not be worked during the summer, it is advisable to work the entire crop strip, but leave an unseeded strip on each side as in strip fallow. In this case it will be necessary to spread bait over the entire protective strip. Where a good stand of grass exists, the possibilities of infestation are considerably lessened.

Stubble Burning. Stubble burning will destroy no 'hopper eggs. It will, however, result in an earlier and more even hatch. Since stubble burning is an undesirable agronomic practice, it is very questionable whether it is justified for grasshopper control.

Plowed and Plowless Fallow. Since fallowing is usually started after a considerable number of 'hoppers have hatched, no appreciable number will be killed by either plowed or plowless fallow. If, when fallowing is started, a considerable infestation of young 'hoppers is present, poisoning should be resorted to before fallowing. Again, working toward the center and leaving an unworked strip, will concentrate the population where it may be poisoned more easily. Trashy cover will not invite egg laying unless green vegetation is present. Any field to be fallowed should be carefully watched. If 'hoppers are hatching in considerable numbers, and fallow operations must be delayed, the field should be thoroughly baited.

Field Hedgerows. Field hedgerows, whether trees, shrubs, or annuals, such as corn and sunflowers, tend to concentrate egg laying of the fence-row species. For that reason the area should be carefully watched during the hatching period.

Say's Grain Bug (*Chlorochroa sayi* Stal.) has been more or less injurious to wheat in Montana since 1932. This pest hibernates beneath trash during the winter, emerges in the spring, and usually completes at least a generation on annual weeds such as Russian thistle and tumbling mustard. As these dry up, the insects migrate to other succulent plants. Grain fields often are heavily infested.

The injury which Say's Grain bug does is of two general types. Feeding on the stems often kills the head as it develops. Later feeding is usually on the heads as the berries are forming.

The kernels are tapped and the resulting grain is shrivelled and greatly reduced in quality.

The only recommendation for the control of this insect at the present time involves the fall or early spring burning of roadsides, piles of dead weeds, loosely piled straw, and similar situations which afford winter shelter. This will not kill many of the bugs in itself, but it will expose them to the weather and chances of winter killing will be increased.

A burning program should not be undertaken without thoroughly considering the possible effects of the wind on the bare soil. Studies are being carried on at the present time to ascertain the relationship between grain bug populations and abandoned or idle lands which have grown up to annual weeds.

The Wheat Stem Sawfly (*Cephus cinctus* Norton) has been the cause of much injury to wheat in the prairie provinces of Canada and occasionally has been noted in injurious numbers in northern Montana. The adult is a rather slender black wasp with lighter bands across the body. It lived on native grasses originally, and has been transferred to wheat as this crop has replaced native grasses. The eggs are laid in grasses with hollow stems and the elongate yellowish white larvae work up and down the stems. As the wheat ripens, they go down toward the crown, girdle the stems, and then go on down to the roots. The stalks break off, and the larva spends the winter near the crown of the plant. Pupation takes place and the adult sawflies appear in June of the following year.

The fact has been established by Canadian entomologists that, while eggs are laid in oats and brome grass, the larvae will not mature in these crops. Wheat and rye, among cultivated crops, are most seriously affected. Crested wheat grass is not preferred, but larvae developing in this crop will mature.

The females are weak fliers, and usually do not travel far in search of hosts. In infested areas, stubbling in of a crop is very likely to increase the injury the following year. Likewise, strip farming, when the alternate strips are planted to grain on alternate years, may provide new hosts beside infested stubble, thus increasing the chances for loss. The field should be planted

to oats the year before stripping is to be started, and a permanent brome grass strip should surround it.

Trap crops have been found to provide excellent protection to crops in Canada. A strip of oats or barley 20 to 30 feet wide should be planted, between infested fields and new plantings, at least two weeks before the grain crop is planted for harvest. Brome grass can be planted as a permanent trap. The larvae are destroyed, either by the host itself in the case of oats or brome, or by cutting the trap crop before the larvae go down to the crowns. This is usually about the middle of July. If a badly infested field is to be fallowed or planted to some non-grain immune crop such as flax, corn, or a legume, a trap strip around such a field will stop most of the egg-laying adults as they spread out in search of host plants.

The pale western cutworm (*Agrotis orthogonia* Morr.), an insect native to the great plains area, is at times exceptionally injurious to wheat. Its appearance and disappearance is dependent on spring and early summer rainfall, and its control dependent on tillage methods.

As was shown by the Montana Agricultural Experiment station years ago, the adult pale western cutworm moths prefer to lay their eggs in dusty soil. The egg laying season is roughly from the middle of August to the middle of September. Therefore, if a field is to be planted to winter wheat or rye, the surface should be allowed to crust and this crust should not be broken by tillage before the middle of September. Recently H. L. Seamans, of the Dominion Entomological Laboratory of Lethbridge, Alberta, has shown that fields infested with little cutworms can be cleared of the pests and spring crops planted with small danger of injury.

After the tiny larvae have fed they are rather easily starved. A field in which injury is anticipated should be allowed to green up in the spring until the vegetation is approximately 2 inches high. It then should be cultivated so that no green vegetation shows above the soil for 10 days. After that period it is safe to plant spring crops. This control method will not work, however, if the field is primarily infested with fanweed (*Thlaspi arvense*) for this plant is not fed upon by the pale western cutworm.

When once a crop is infested, it is impossible to eliminate these pests. Hence the control methods outlined above, which are employed before the crop is seeded, should be followed with care whenever an infestation is anticipated.

The Relationship of Soil Erosion to Land Use

By

H. G. BOLSTER

Extension Land Economist

The preceding sections of this bulletin dealt primarily with the extent, causes and control of erosion. Here it is proposed to discuss some aspects of soil losses in relation to land use.

Land use is perhaps the most important factor in the whole erosion problem. Improper land use results in soil losses and any erosion control program which fails to take this factor into account can never be entirely successful. Nature imposes certain limitations on the use of land. Soils, climate, and topography are quite definitely fixed and if the use of land were in complete harmony with these physical limitations, erosion as it is known today, would be of little concern. Unfortunately, man, either because of ignorance, greed, custom, or economic pressure, often disregards these fixed limitations to the use of land and thus destroys nature's balance.

Maladjustments in the use of land are usually more pronounced in newly settled areas. There appear to be two principle reasons for this: First, many of the settlers to new areas have had but one thought in mind—to make a "stake" and then move on to repeat the process. Second, absence of reliable guide-posts concerning climatic conditions, soil resources, adapted practices, etc. The exploitation which results from such conditions causes untold losses of human and natural resources and must inevitably be followed by a long and painful period of readjustment. The homestead era of Montana was no exception to the rule and the mistakes which were made during that period were largely responsible for many of the pressing problems with which the people of the state are faced at the present time.

Many factors have contributed to bring about these present difficulties. To begin with the policy of allotting 160 and 320 acre homesteads was, of course, clearly a mistake in view of the experiences of the past two decades. For a time these units appeared to be satisfactory for providing a living for the average operator. From 1908 to 1918, which was the period during which the heaviest settlement took place, new land and favorable climatic conditions produced high crop yields in all sections of the state. At the same time prices were on the up-swing. Under these cir-

cumstances the early settlers were not only misled as to the future productivity of the land but were encouraged to develop public services which later proved to be an excessive burden. Later, under less favorable price and climatic conditions it was clearly demonstrated that many units were too small for economic operation and that the type of farming and methods used were not suited to the physical limitations of the area. Soon farmers found themselves faced with insurmountable burdens of debt which had been incurred to meet operating losses. Mortgage foreclosures and tax delinquencies rose rapidly and the period of readjustment was at hand.

This adjustment process has been going on more or less continuously for the last 20 years. During that period farmers, particularly of the plains area, have been engaged in a desperate struggle to retain or salvage something of the fruits, which in many cases, represented a quarter of a century of effort. Under such circumstance the land usually fares rather badly. And even though farmers may recognize now that their farming operations are not being conducted in accord with the natural limitations of the area there are, in most cases, but two courses open to them; either they must abandon the land or attempt to exploit it. Small, uneconomic units, debts, taxes, and other economic problems, make it impossible for the average farmer to follow conservation practices without outside assistance. Conservation problems, therefore, involve not only physical but social and economic problems as well. This thought was most ably expressed by Dr. H. H. Bennett, chief, Soil Conservation service, when he said, "But social and economic factors must temper the ideal physical program, for conservation of soil is not an end in itself—it is not worth while simply because the principle of conservation seems desirable. The true value of protection for the Nation's soil and water resources is found only in the present and long-time benefits which such protection brings to all the people."

To deal effectively with our soil conservation and land use problems will require the united efforts of the individual farmer and the several state and federal agencies responsible for assisting in the solution of these problems. Working together, they must, after a thorough study of problems and resources, determine, insofar as possible, the future best use of each separate area. Based upon this knowledge a detailed unified program must be developed which will deal, not with individual problems, but with problem masses. In other words, the program, while it may have many different parts, must essentially be but one program as it relates to the area or individual farm.