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PASTURES IMPROVED

WITH

Tillage
Treatment
Seed

Pastures Improved with Tillage - Treatment - Seed

Bulletin 327 (Revised) June 1950

Part I

SMALL PLOTS TRIALS

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Part II

PASTURE RENOVATION

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MORGANTOWN
IN COOPERATION WITH THE SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

Pastures Improved with Tillage-Treatment-Seed

Part I

SMALL PLOTS TRIALS

THERE IS no longer any doubt that lime and phosphate fertilizer applied on the surface give profitable improvement of permanent pastures over most of the state (7, 8, 11, 12, 13). In addition, the benefits from mowing are widely recognized. These practices require an outlay of cash and labor above that required for grazing unimproved pasture, but the returns, measured by animal gains and milk production, are so much greater that successful farmers cannot afford to neglect lime and phosphate treatment and pasture mowing.

Experience has shown that the greatest response to surface treatment with lime and phosphate occurs where the pasture vegetation contains a fair proportion of desirable grasses and legumes. But many pastures have now become so poor that few desirable plants are left. In such cases surface treatment is slow in bringing about improvement. The initial response is seen in greater yields of wild grass and weeds, and it may be several years before much white clover and bluegrass are seen. In the meantime the farmers may become discouraged and lose faith in the long-time value of pasture treatment.

The seeding of desirable pasture plants requires an additional outlay of cash and labor above that required for surface treatment, but this may be necessary for the most rapid and profitable improvement on many poor pasture areas. With this in mind the study was started. The objectives were:

- (1) To compare the effectiveness of different methods of improving poor pastures, so that farmers would have a better basis for deciding whether or not to reseed in addition to treating with lime and fertilizer, and

(2) To provide information as to the most effective and practical methods, seed mixtures, and management necessary to obtain the desired results under various conditions.

Plan and Procedure

The first trial seeding in this study (15) was made on a poor pasture on the Agronomy Farm at Morgantown in the early fall of 1941. This trial consisted of a strip on the contour, part plowed and worked into a good seedbed, part disked, part surface-treated, and part untreated. Plots were replicated three times. There were also two fertilizer variables as well as the comparisons involving tillage.

In the spring of 1942 a similar trial was started on the same area. In the spring of 1943 another trial was begun at Morgantown as well as one at Wardensville, plus cooperative field trials in Nicholas, Wetzel, and Greenbrier Counties. These field trials were made in cooperation with the Agricultural Extension Service, the Soil Conservation Service, and individual farmers. The primary emphasis was placed on a comparison of surface-treated pasture with pasture that was tilled and reseeded as well as treated. Untreated pasture was also compared in most cases. The following simple trial plan was used, as previously described (15), with such modifications as seemed desirable at the different locations:

Manure was used to top-dress one-half of the area wherever possible. Lime and fertilizer treatments were uniform on each area and were adapted to the particular requirements of the soil and seeding insofar as these could be judged by soil examination and testing. Seed mixtures were uniform on each area comparing different tillage methods, but were not exactly the same on all different areas. The following was approximately the seeding used:

TILLAGE, TREATMENT, SEEDING gave quick and excellent improvement on this typical poor hillside pasture. The light area is a seedbed.

	lb. per acre	
Alsike clover	2	to 3 (or red clover 6 lb.)
Louisiana white clover	1	
Korean lespedeza or sweet clover..	3	to 5
Kentucky bluegrass	3	to 5
Orchard grass	2	to 5
Ryegrass	4	to 5
Redtop	1½	to 3

Birdsfoot trefoil (1 lb.), timothy (3 lb.), alfalfa (4-5 lb.), Ladino clover (1 lb.), and other grasses and legumes were used on certain areas.

Additional trial seedings have been made each fall and spring since 1943. Most of these have consisted of a simple comparison between standard surface treatment and some kind of tillage, surface treatment, and seeding in addition to standard treatment. Improvements in methods and seed mixtures account for the more consistent success from tillage and seeding in the trials established during 1944, 1945, and 1946. Pasture seedings have been made in the following counties: Monongalia, Harrison, Hancock, Wetzel, Greenbrier, Nicholas, Putnam, Mason, Tyler, Hardy, Hampshire, and Grant. The sites represent conditions over a large part of the state.

Evaluation of results has been attempted by several means (15). The regular procedure has consisted of placing wire pasture cages on each plot or strip and harvesting the growth three to five times during the season. In the early trials, four replicate cages were used to sample each different strip. These cages were moved to new locations at the close of each season in order to get a good indication of the effect of grazing. In some later trials no cages have been used, or only a few cages have been placed to give an estimate of the growth.

At all caged locations, species and ground cover estimates have been made in the spring and fall. On areas not caged, some of these detailed

estimates also have been made, supplemented by periodic observations and detailed notes. Data are given in the tables only on areas where yield records have been obtained, but much valuable experience has been obtained at other locations as well.

Since protein yield is often a better index than total yield of pasture, the harvested forage has been analyzed for protein to assist in an accurate evaluation of yields.

Other features of evaluation, such as relative palatability to grazing animals, and soil losses by erosion are difficult to measure or express, but these have been studied and considered in evaluating the results and in reaching conclusions.

Experimental Results

TOTAL YIELD OF HERBAGE

The Seeding Year

The aim in tillage was to destroy the existing vegetation and to provide a suitable seedbed for the newly seeded species. Estimates of cover made during the seeding year showed that, in general, this aim was accomplished.

Figure A gives the average per cent of ground cover consisting of desirable species. This shows that by tillage and reseeding, the desirable species had been increased from about 9 per cent on the surface-treated areas, to about 34 per cent on the shallow-tilled areas, and to 40 per cent on the plowed areas. Inasmuch as these estimates were made within the year following seeding and it takes time for the newly seeded species to form a good sod, it appears that a reasonably good job of seedbed preparation had been accomplished.

Furthermore, Figure A shows that the yield on the tilled and seeded areas was as high or higher than on the surface-treated area. This is significant because it indicates that the newly seeded species were producing as much during the year of seeding as was the native vegetation.

Considering the higher content of desirable plants and at least an equal total yield, it is apparent that the feeding value of the newly seeded pastures was considerably greater than those receiving surface applications of lime and fertilizer.

Protein content, which is related to feeding value, was determined for some of the areas. The results are shown in Table 2. These show that the highest percentage and greatest total yield of protein were secured on the shallow tilled plots, followed in order by the plowed areas, the surface-treated areas, and the untreated areas. The high protein content of the surface tilled areas was a direct result of the relatively high percentage of the yield from the legumes seeded in the mixture. The plowed areas had less legumes but more young, desirable grasses which have a higher protein content than the native species present in the undisturbed areas.

FIG. A—HIGHER YIELDS and more desirable species from renovation on ten areas are shown. Plowing, shallow tillage, and surface treatment during three seasons are compared. There was no protection from grazing.

Plowed areas usually showed the most bare space (poorest cover) during the seeding year. Exceptions to this were noted where the original vegetation was very poor, in which case the untreated areas showed the most bare ground.

The areas selected, in most cases, had little bluegrass or white clover to respond to surface treatment. Under such conditions response to surface treatment with lime and fertilizer would be expected to be relatively slow. One pasture with 61 per cent desirable species, however, was disked and reseeded. In this case, during the seeding year the yield was reduced by 40 per cent and quality of the herbage was poorer on

TABLE 1. SUMMARY OF RELATIVE YIELD AND SPECIES COMPOSITION ON VARIOUS PLOTS DURING SEEDING YEAR*

TILLAGE	NUMBER OF TRIALS SHOWING HIGHEST TOTAL			
	Yield	Desirable Species	Legumes	Bare Space
Plowed	2	7†	0	8†
Shallow-tilled	7	6†	12	1†
None	2	0	0	3

* All plots were limed and fertilized equally in each comparison.

† Plowed and shallow-tilled were estimated as equally bare in two trials and as having equal desirable species in one trial.

the tilled area. In general, the results showed that the poorer the pasture vegetation, the greater the response to be expected immediately following reseedling.

Differences in stand caused by differences in degree of tillage and by seeding dates were also evident. Seedlings made in the early spring or in August have been consistently successful when treatment and tillage were adequate. A thorough tillage job was necessary to get rid of the old vegetation and to assure a good stand, as indicated by the estimated percentage of desirable species and by the percentage of the total ground cover which is desirable species. Unless most of the ground cover is shown as desirable species, this means, of course, that much of the old grass and weed cover remains.

Slope and exposure did not show any marked influence on the results. It should be noted, however, that many successful trials have been carried out on relatively steep slopes, such as are typical of the largest poor pasture areas in the state.

Soil types had a definite influence on the results, as will be discussed later. The trials shown are on soil types that represent quite extensive areas in the state.

TABLE 2. PROTEIN CONTENT AND TOTAL PROTEIN YIELDS OF HERBAGE FROM SEVERAL PASTURE-TILLAGE TRIALS DURING SEEDING YEAR

LOCATION	UNTREATED		SURFACE-TREATED		PLOWED		SHALLOW-TILLED	
	Per cent	Lb./ Acre	Per cent	Lb./ Acre	Per cent	Lb./ Acre	Per cent	Lb./ Acre
#4 Wetzel Co.	8.00	130.6	9.12	217.5	11.69	231.9	13.50	308.8
#5 Wetzel Co.	7.75	53.7	7.87	53.7	16.69	219.4	18.13	678.7
#6 Greenbrier Co.	11.12	63.7	11.44	77.5	13.25	115.0	14.56	144.4
#7 Greenbrier Co. ....	.....	.....	12.63	132.5	14.00	217.5	13.44	266.3
#8 Nicholas Co.	9.19	98.7	9.62	110.0	11.50	173.1	10.75	248.1
#9 Nicholas Co.	7.25	108.1	7.69	92.5	13.88	.....	11.19	.....
#10 Nicholas Co.	9.06	113.7	8.25	117.5	13.69	104.4	11.31	107.5
#14 Hardy Co.	10.90	89.6	13.50	223.6	15.20	404.5	17.10	503.8
#15 Hancock Co. ....	.....	.....	6.80	44.5	.....	.....	12.80	127.0
#16 Hancock Co. ....	.....	.....	6.50	65.1	.....	.....	15.40	384.4

TABLE 3. SUMMARY OF RELATIVE YIELD AND SPECIES COMPOSITION ON VARIOUS PLOTS IN YEAR FOLLOWING SEEDING YEAR*

TILLAGE	NUMBER OF TRIALS SHOWING HIGHEST TOTAL			
	Yield	Desirable Species	Legumes	Bare Space
Plowed	2	5	2	7
Shallow-tilled	9†	6	8	0
None	1†	0	1	4

* All plots limed and fertilized.

† Yields were equal on disked and surface-treated pasture in one trial.

The Second Year

Certain consistent characteristics in comparisons involving plowing, shallow tillage, and surface treatment are indicated in Table 3 and in Figure A. Several changes appear in comparison with the first year's results. The total yields are more favorable to the reseeded plots, the total desirable species are rather similar on most plowed and shallow-tilled plots, and legumes have become highest on two plowed and one surface-treated plot. The high legumes on the one surface-treated plot represent a case where wild white clover made outstanding progress after treatment. Bare space remains highest either on plowed or on extremely sparse surface-treated plots. Protein analyses show a continued advantage from seeding (Table 4) in most cases. The second year's results apparently show the maximum advantage from reseeding in most cases.

The Third and Fourth Years

Yield differences and desirable species for the third year are shown in Figure A. In general there is no great difference between most shallow-tilled and surface-treated pasture during the third year insofar as dry-weight yield is concerned, but vegetative estimates indicate some superiority in quality for the tilled and the seeded plots. Wetzel County trials show the greatest continued advantage from seeding, but surface

TABLE 4. PROTEIN CONTENT AND TOTAL PROTEIN YIELDS OF HERBAGE FROM SEVERAL PASTURE-TILLAGE TRIALS DURING SECOND YEAR

LOCATION	UNTREATED		SURFACE-TREATED		PLOWED		SHALLOW-TILLED	
	Per cent	Lb./ Acre	Per cent	Lb./ Acre	Per cent	Lb./ Acre	Per cent	Lb./ Acre
#3 Morgantown	10.4	51.2	11.7	232.4	11.7	229.9	13.5	268.1
#4 Wetzel Co. ....	.....	.....	13.0	56.2	11.2	260.7	13.6	181.2
#5 Wetzel Co. ....	.....	.....	11.2	114.9	14.6	537.9	17.4	759.0
#6 Greenbrier Co. ....	.....	.....	12.0	118.5	12.4	155.0	14.1	239.8
#7 Greenbrier Co. ....	.....	.....	11.9	153.5	13.4	289.4	12.9	290.3
#8 Nicholas Co.	8.9	81.7	9.7	99.5	11.8	141.6	11.9	144.2
#9 Nicholas Co.	9.0	72.9	10.8	145.8	12.2	140.5	12.2	190.3
#11 Greenbrier Co.	11.5	260.1	13.1	375.7	.....	.....	14.7	604.2

TABLE 5. SUMMARY OF TILLAGE TRIALS*

TILLAGE	YIELD	BARE GROUND	DESIRABLE SPECIES		PERCENTAGE OF THE TOTAL HERBAGE IN DESIRABLE SPECIES
			Total	Legumes	
	(lb./acre)	(per cent)			(per cent)
Plowed.....	1,126	58	32	7	76
Disked.....	1,492	53	33	9	70
Surface-treated...	1,485	53	26	8	55

* Records for the fourth year after seeding.

treatment is beginning to bring about marked improvement in all cases, so that even in these trials there is less difference due to tillage and seed. There is still considerable difference in the proportion of the total herbage which consists of desirable plants. In those later trials where the original vegetation was extremely poor, the advantage from seeding should be greater through the third year than the average of the early trials. The early trials represented more varied conditions, some of which were unfavorable to reseeding.

Two trials at Morgantown have now gone through four years. The seeded pasture continues to show a somewhat superior species composition compared to the surface-treated pasture. A summary of these trials during 1945 gives the results shown in Table 5.

The yield on the plowed areas is lower than on the disked or the surface-treated pasture. Continuous overgrazing, which is usually worse on the plowed seedings, is probably beginning to have a damaging influence on the yields.

SEASONAL DISTRIBUTION OF YIELDS

During the first year the distribution of yield was affected by time of seeding and by weather conditions. But with spring seedings the late-summer growth on tilled plots was usually larger and was a higher percentage of the total yield than such growth on the surface-treated plots. In an extreme case in Hancock County, over 1,700 pounds, or more than 70 per cent of the total yield, was obtained after July 20 on the tilled area, whereas almost 100 per cent of the yield from the surface-treated pasture was obtained before that date. The average for 1943 shows late-summer yields as follows: plowed 44 per cent; shallow tilled, 35 per cent; surface treated, 28 per cent; and untreated, 28 per cent of the total. In 1944 four new seedings on which yields were measured showed 67 per cent after July 20 on the tilled plots compared to 33 per cent on the surface-treated pasture. These yield differences are distinct but are less than they would be except for the heavy midsummer yields of broomsedge on some of the surface-treated areas. The quality of the broomsedge yield is so poor, especially in midsummer, that the actual difference in yield of palatable herbage due to reseeding is much greater during the first year than is indicated by total dry weights.

After the seeding year, differences in seasonal distribution of yield might be expected because of the different species introduced. But de-

TABLE 6. DISTRIBUTION OF YIELDS AT MORGANTOWN DURING THE 1943 SEASON

PERIOD	DISKED	SURFACE-TREATED
	(per cent)	(per cent)
Before May 13	27	33
May 14-June 7	27	25
June 8-July 2	11	10
July 3-July 27	12	10
July 28-September 2	18	16
September 3-October 7	5	6

tailed results show that for most areas the difference is small. A comparison of percentage yields for 1943 is given in Table 6.

This example is typical of results on many areas. Total yields, however, do not tell the whole story. The tilled area had 40 per cent desirable species compared to 22 per cent for the surface-treated area. This difference in species caused a corresponding difference in palatability and undoubtedly resulted in higher utilization of the herbage on the tilled pasture. This was evident from observation throughout the season.

Failure of the dry-weight yields to show different seasonal distribution to any great extent after the first year was due in part to the greater abundance of broomsedge and of hot-weather weeds on the unimproved and the surface-treated pasture. These plants, as already mentioned, make considerable growth in dry weather, when the bluegrass is dormant, giving a seasonal distribution of dry-weight yields similar to that of the seeded species. The other main reason for similar seasonal distribution is the close grazing on seeded areas. It is known that rotational grazing and maintenance of considerable top growth are necessary to obtain maximum root development and maximum total yield from many forage plants. Alfalfa and orchard grass or brome grass, for instance, will give high midsummer and highest total yields only if grazed so that there is considerable (more than 6 inches) top growth most of the time. Ladino white clover and orchard grass or other grass, too, will give maximum yields only if allowed time to grow 8 to 12 inches of top between alternate periods of grazing. Closely grazed permanent pastures are not suitable for high midsummer yields regardless of the species involved, except for the vigorous midsummer growth of legumes which can normally be expected during the seedling year.

EFFECT OF RESEEDING ON WEEDS

Surface treatment usually lowers weed content, but shallow tillage and plowing were even more effective wherever weeds were abundant in the original turf. This is caused in part by the destructive action of tillage, but also by the high palatability of the forage on the tilled and seeded areas. Grazing animals are so attracted by the newly seeded species that they eat and tend to kill out even such unpalatable species as greenbrier, running brier, goldenrod, ironweed, and others. Annual weeds such as ragweed and crabgrass are sometimes more abundant

SHARP TILLAGE TOOLS and sometimes extra weight are needed to penetrate complete sods of poverty grass and weeds like those shown above. Shallow plowing often works well in seedbed preparation when other tillage fails.

following tillage. But these do not persist if the seeded species make good growth.

FACTORS IN IMPROVING POOR PASTURES

As previously indicated, observations were made on various factors which appeared to influence the results from reseeding. Most of these factors cannot be expressed in absolute terms. The observation made here together with observations in other places make it possible to evaluate, in a general way, some of the conditions which are associated with the success or failure of reseeding.

The Original Pasture Herbage

Since pastures with no desirable species give slowest response to surface treatment, these are the areas most commonly considered for reseeding. Stands of pure grass, even of desirable grasses like Kentucky bluegrass or orchard grass, also may be improved by shallow tillage and seeding with legumes as is recommended in Wisconsin (1, 2). This practice requires a different type of grazing management than that used.

Excellent results from reseeding have been obtained in a wide variety of inferior native grass or weed covers. Shallow tillage has often

MORE THOROUGH TILLAGE would be desirable on this poverty-grass sod, but March seedings—especially with legumes—give valuable stands on this type of seedbed. No erosion will exist here, even with close grazing.

been accomplished with difficulty where the native herbage is dense. Greenbrier, goldenrod, ironweed, blackberry, running brier, sumac, broomsedge, and other tough perennials are among the most difficult to tear loose. If the top growth is dense, it may be necessary to cut and rake it off before tillage is feasible. But a satisfactory seedbed can usually be prepared by stirring the soil among the old roots, even though all these cannot be torn out. The palatable young seedlings are so attractive to livestock that much of the weed or native-grass growth will be grazed and retarded or even killed out.

Areas with smaller, shallow-rooted perennials like cinquefoil, ladies tobacco, milk spurge, and poverty grass or small annuals such as chickweed, crabgrass, and triple-awn grass were found to be much easier to till with a disk or spring-tooth harrow. In the case of dense poverty-grass cover there may be some difficulty in getting the disk or harrow teeth to penetrate the soil. A sharpened tillage tool will usually solve this difficulty.

The nature of the vegetation may determine both the best methods and the best season for working the ground. But the fact that the natural herbage is extremely undesirable and unproductive is not proof that the pasture is incapable of high production. Some of the best results from reseedling have been on pastures where the natural herbage seemed to indicate that improvement was hopeless.

ONLY SIX WEEKS after seeding on the minimum-tillage job shown in the preceding picture, this quick stand of legumes (white and alsike clover) covers the plot. The high palatability of the legumes causes close grazing.

The Nature of the Soil

The soil is closely associated with and often determines the nature of the pasture herbage. The soil also influences the results directly in ways that cannot be predicted from the herbage. For example, at Morgantown it proved impractical to prepare a proper seedbed on silt loam soil in the fall with a dull harrow. Where the soil was a sandy loam, however, there were no serious difficulties. Similarly, the light-textured soils of Hancock County have proved to be much easier to work than some of the heavier-textured soils of Wetzel and Greenbrier Counties. Shaley, gravelly, or even stony soils are usually easy to work, especially with a spring-tooth harrow or cultivator, because the vegetation is torn out when the rock materials are loosened. Disking is more difficult except where the rock consists of soft shale, which is readily cut.

Soil structure and organic-matter content also influence the ease of tillage. Eroded Upshur clay subsoil or other massive clay subsoils are very difficult to work, but Upshur surface soil with good organic-matter content offers no great difficulties.

In addition to the direct influence of soil on seedbed preparation the soil also will influence the rate of seeding and the kind of seed mixtures used. Higher rates of seeding have been found necessary on soils low in organic matter and subject to drought. Likewise, soils subject to

dry weather should have a large proportion of drought-resistant grasses and legumes, as will be indicated later.

After a good job of reseedling has been completed, it should be realized that the absolute return will differ greatly on different soils. Deep, productive soils with superior native fertility, high organic-matter content, and good water-holding capacity give more return than less productive soils. One area in Wetzel County and another in Greenbrier County have given very high yields since the limiting factors, lime and phosphate, have been corrected, and seeds of productive plants have been supplied. But certain other areas can never be expected to give more than moderate yields since they are on droughty soils with low organic-matter content and low fertility. This is a very important point, because the total return on soils of low capabilities may not pay for the cost and effort of improvement; but where the limitations are easy to correct, the total return and the profit may be great.

Lime, Fertilizer, and Manure

As previously indicated, lime and fertilizer treatments were uniform on each area, but there were variations in different areas depending upon soil conditions. Consequently all information on lime and fertilizer have been arrived at by observation of results under different conditions and by general knowledge of the soils. As a result, only very broad conclusions can be drawn regarding various fertilizer and lime treatments.

In most tillage and reseedling trials a rate of approximately 2 tons per acre of finely ground limestone has been used, but variations from this rate have followed soil tests. Higher rates can often be used to good advantage, especially on soils that are low in bases. Tillage mixes the lime with several inches of soil; hence higher lime rates are likely to be more profitable than in the case of simple surface treatment. A minimum pH of 5.8, and preferably a value of 6.5, should be obtained in the surface soil for good results.

The commonly recommended phosphate rate of 500 pounds of 20 per cent per acre has been used in most trials. As in the case of lime, higher rates may be used to advantage, particularly on heavy clay soils. Unless phosphate fertilizer has been applied recently, it is safe to assume that practically all poor pasture should receive phosphate treatment. Soil tests are helpful if there is doubt.

The best evidence now available seems to indicate that potash fertilization for pasture seedings is beneficial on strongly leached sandy and silty soils and on soils that have been very heavily cropped without much return of residues. Low organic-matter contents are usually associated with these conditions. For continuously high-yielding, managed pastures it is likely that potash fertilization will prove profitable on many soils over a period of time. Even so, it should be remembered that West Virginia soils as a whole, and especially pasture soils, are not so deficient in potash as are the soils of certain other regions such as New England and the Coastal Plains. Serious potash limitations do not occur in pastures until lime and phosphate supplies have been built up to a high level (10, 13, 14).

LIME, PHOSPHORUS, TILLAGE, SEED are responsible for the good stand of orchard grass, ryegrass, and mixed clovers in the bottom photograph. Compare it with the plot above from the same picture. It is typical poverty grass and cinquefoil, shows extremely poor growing qualities.

OVERGRAZING of new seedings, as seen in the foreground, exposes the soil and leads to erosion. Protective top growth as pictured inside the cage prevents soil loss, assures a better stand, and gives higher yields.

Nitrogen fertilizer has been used in a number of trials and has greatly stimulated the early growth of the grasses. Its effect has seemed to be more marked on shallow-tilled than on plowed seedbeds, suggesting that the surplus of litter causes bacterial tie-up of available nitrogen and thus retards the grasses in their early growth. The final stands of grasses on trashy seedbeds seem to be improved somewhat by early nitrogen top-dressings but the differences are not so great. Thus nitrogen is most likely to be profitable when applied early on new, trashy seedings where a maximum of pasturage is needed and is to be eaten immediately.

Manure seems beneficial on pasture seedings in several ways. It supplies nutrients, serves as a mulch, and helps to prevent overgrazing and to prevent erosion. These several benefits seem to justify application of light top-dressings of manure to new pasture seedings, especially where the seedbed has been prepared by plowing. At one location in Greenbrier County a marked benefit from manure was seen on the plowed strip, and less benefit on the disked. This result is consistent with appearances at various other locations. The shallow tillage seems

NO LIVESTOCK would relish this pasture. The herbage is too coarse. Shallow plowing often is the most satisfactory method of preparing a seed-bed on this type of sod. A spring-tooth harrow will work well at times.

to afford at least a part of the benefits that are supplied by manure on plowed ground.

Tillage Tools

There is considerable interest in new tools for shallow tillage of pasture and meadow land, and undoubtedly improved tools would make such work easier and quicker. But after several years of actual experience in establishing field trials using the tools available on various farms, the evidence seems clear that most tillage in pastures can be satisfactorily accomplished with the available tools. In some cases heavy grazing will help to get rid of excess weed and grass growth; in other cases some mowing and raking may be necessary; and in most cases attention must be given to the proper season and to working when the ground is moist and soft.

The three tools that seem most promising as means of reseeding pastures are the plow, the disk, and the spring-tooth harrow. Field cultivators and spike harrows also may do well in some cases. "Bush and bog" harrows are highly effective and act similarly to a very

THIS EXCELLENT COVER came from an August seeding. There are Ladino clover, alsike clover, and mixed grasses in abundance. The seedbed was prepared with a spring-tooth harrow. Seeding rate was 1 lb. of Ladino, 3 lb. of alsike, and 13 lb. of mixed grasses per acre (5 lb. orchard grass, 5 lb. ryegrass, and 3 lb. Kentucky bluegrass). This same plot is pictured in the preceding photograph before it received a proper seeding.

heavy disk, but they are a scarce tool in West Virginia. Heavy tools are naturally more effective than light ones, but well-sharpened, light tools will usually do the job, especially if some extra weight is added. Several seedings on "shallow-plowed" seedbeds have given good results and indicate that extremely shallow and trashy plowing is an effective method of preparing shallow seedbeds in those cases where tillage is difficult with disk, harrow, or cultivator. If the plowing is less than 3 inches in depth, the major beneficial effects of shallow tillage are obtained.

One major soil factor which favors shallow tillage as compared to plowing under West Virginia conditions is the normal concentration of soil organic matter near the surface of old pasture sods. In 10 comparisons the organic-matter content of the 0-1½-inch layer was 4.4 per cent, of the 1½-3-inch layer 2.2 per cent. The normal content at 6 inches is about 1.0 per cent. In many cases this is believed to be a more important factor than the surface trash, which receives more

PLOWED, WELL WORKED SEEDBED appears on left. At right is a thorough shallow-tillage job—vegetation torn out but left in surface layer.

attention because it is readily seen. Because of the rapid decline in organic matter with depth, seedlings on old pasture sods plowed to normal depth must start growth in soil with less than one-half as much organic matter as seedlings on shallow-tilled soil. This factor would not apply in the case of pasture land recently converted from crop land, and some disappointing results on old cropped soils may be expected unless manure is applied and grazing controlled (10, 14).

Preparation of the Seedbed

Under ideal conditions it has been possible to prepare good pasture seedbeds at almost any season. August seedlings have been successfully carried out both by plowing and by shallow tillage, but early spring offers the most promise. Plowing (preferably very shallow) may be the only means of preparing a satisfactory seedbed for August seedlings on ground that is hard to work, but in winter and spring other tools will usually work well. On pastures with much vegetative cover there is very little danger of working the ground too wet. Tillage can be performed in the fall or winter, or in the early spring long before it is dry enough for other farm work on cultivated ground. This is one advantage of shallow tillage of pastures. It can be done at a season when other farm work is not urgent.

In general, a trashy seedbed is not considered satisfactory unless at least 75 per cent of the native vegetative cover is torn out of the ground. Results, however, indicate that seedlings, especially with legumes, may be worth while even though only half of the old herbage is destroyed.

DIFFERENT STANDS are produced from the types of seedbeds shown in the double photograph on page 20. On the left, ordinary plowing gave excellent grass and fair legumes. Thorough shallow tillage, on the right, produced excellent legumes with fair grass, although not all weeds were destroyed.

If the seed is applied in early spring and is followed by grazing, a fair-to-good stand of clovers can be obtained with a minimum of seedbed preparation. Some grasses, especially orchard grass, also can be obtained by this means; but the stands will not approach that on plowed seedbeds.

Deep plowing for hill-land pasture seeding does not seem desirable. Shallow, trashy plowing is sometimes the most practical method, and it offers most of the advantages of deep plowing without sacrificing certain advantages of shallow tillage. All plowed seedbeds are probably better if they have time and rain to settle them before seeding. In late summer seedings, the settling is usually essential for consistent success.

Shallow, trashy tillage as with a disk or harrow requires no settling, and the rough, irregular surface sometimes left by a spring tooth is no cause for concern. The roughness will disappear in a short time, even when large mounds of trash remain. Rolling or cultipacking has not seemed to be beneficial in the case of shallow, trashy seedbeds. Good stands have been obtained by this means, but some of the best stands have been obtained by light covering of seed with a disk or a spring-tooth harrow.

Light covering of the seed is safer for most seeding made later than March. There seems to be less danger of covering too deeply on trashy than on normally plowed seedbeds and also less danger from no coverage at all. The trash and the high soil-organic-matter content permit considerable latitude without the normal hazards.

Climate and Rainfall

The wide variations of elevation, rainfall, and temperature in West Virginia do not permit broad generalizations. Since seedlings have now been made during four complete seasons and at various locations, however, there seems to be reasonable assurance that the results represent a fair cross section of what is normally to be expected. During this time there have been no complete failures of legumes on well-treated shallow-tilled plots. Several plowed seedlings did fail and others have very thin stands. Cool, moist weather, as is normal in the spring over much of the state, is undoubtedly favorable to new seedlings on trashy as well as plowed seedbeds. On trashy seedbeds, however, there is apparently less danger of new seedlings being killed by hot, dry weather. In two cases dry weather prevented the seedlings from starting quickly, but they made a fair showing later. All fall-seeded plots were thought to have germinated and to have been killed by hot fall weather, but the following season (1944) the spring-toothed plot made fair growth during a rather dry season and in 1945 gave excellent yields. One area, seeded June 16, 1943, was considered a failure until the following year. Then it gave an excellent yield. It continued to yield heavily through 1945. These and other experiences indicate that shallow-tilled seedbeds permit seedlings to live through unfavorable weather that normally kills most seedlings on plowed ground.

Erosion Hazards

Most West Virginia pasture land is so steep that erosion hazards have been considered a serious objection to plowing and reseeding. In order to minimize erosion, the first trial seedlings made in relatively narrow contour strips as described, with surface-treated turf above and below the disturbed strip. This procedure has resulted in rather small erosion losses, but it has the decided disadvantage that reseeding a narrow strip may result in severe overgrazing because of the high palatability of the seeded species. This overgrazing greatly increases the tendency toward erosion. It has been clear throughout that, under most conditions, the greatest danger from erosion is not during the first month or two after plowing. The greatest danger exists later whenever heavy rains occur and when the herbage is very closely grazed. The freshly plowed seedbed is ordinarily loose enough to have high water intake for some time after plowing, but trampling and grazing and the exposure of bare ground may cause serious erosion after the original looseness is lost. Exceptions to this may be found on soils with nearly impervious substrata near the surface, such as Upshur clay or Ashby shaly loam. Special precautions against erosion, including protection from grazing, are advisable with such soils.

Shallow tillage (including extremely shallow plowing) has proved to be quite effective in preventing erosion. Serious erosion has been noted on shallow-tilled seedbeds in only one case. This was a highly erodible soil where a strip, 50 feet wide, was tilled on a 30 to 40 per cent slope.

OLD BROOMSEDGE SOD is shown on the left. On the right, alfalfa, Ladina clover, and orchard grass have been well established by thorough shallow tillage and seeding. This seeding gives excellent yields of high quality forage when managed as a rotation pasture and not grazed continuously.

The protective mat of trash from old vegetation, the high organic-matter content of the immediate surface soil, and the anchoring influences of old plants that are not completely torn out account for the great difference in erosion between shallow tillage and plowing. Erosion is seldom to be expected on shallow-tilled seedings unless the hazard already existed with the old pasture before tillage. Whenever critical areas are reseeded, they should be protected from overgrazing and if possible should be mulched. It should be remembered also that the permanent stabilization of critical areas may require some kind of permanent protection from close grazing such as the seeding of plants that are unpalatable to livestock, or retirement of the land to shrubs or trees.

Legumes and Grasses—Seeding and Management

Since the type of grazing and other management practices often determine the relative dominance of different seeded species, it is appropriate to discuss seeding and management together. If the indicated behavior of various species is first noted, it should be easier to decide upon a mixture that will satisfy the individual need.

White clover: Observations are limited to common white clover from Louisiana and Mississippi, which is known to be suitable for West Vir-

SPRING SEEDING of poverty-grass pasture gave this result the first year. The plowed strip, right, is mainly grasses with fair clover; shallow-tilled strip, left, is mainly clover with fair grasses and some weeds.

ginia conditions. Good results have consistently been obtained, especially on seedbeds prepared by shallow tillage. In the case of seedbeds where a high proportion of the old herbage cannot be torn loose, white clover gives more promise of a stand than any other legume or grass. In mixtures with other legumes, 1 pound per acre has given good results, but where this is the main or the only legume, 2 pounds per acre has given quicker, denser, and more productive stands.

Close grazing usually favors white clover. Tall growth of other clovers (especially sweet clover) and of tall grasses tends to suppress it (7).

Extremely hot, dry conditions are unfavorable for white clover. It does best on moist soils and on soils which are well supplied with lime and phosphate.

Alsike and red clover: Alsike clover has given fair to good results under a variety of conditions. It associates well with white clover and pasture grasses under conditions of moderate to close grazing. It has continued to contribute to the herbage yield for two or three years under most conditions, although in several cases extremely close grazing apparently has killed most of the alsike in the second year. Alsike clover shows less tendency to shade or otherwise suppress the associated white clover than does red or sweet clover. It has given more consistent stands on shallow-tilled seedbeds than red clover, and young plants have apparently been able to survive under closer grazing than most red clover.

Red clover is quite sensitive to close grazing and most plants die after the second year. For these reasons it does not appear to be as promising as alsike clover in pasture seedings. A few old red-clover plants continue to persist on seeded areas as well as on some surface-treated and even on untreated pasture. These plants probably represent particular strains of red clover that are adapted to the pasture conditions, and it is questionable whether seeding ordinary strains will supply any additional, persistent red-clover plants.

Sweet clover: On areas that are known to be limed adequately, sweet-clover stands can usually be obtained by shallow tillage or by plowing. Since common sweet clover is a tall-growing biennial which grows successfully during its second year, only when it has built an adequate root reserve the first year, little will be contributed if a new seeding is to be grazed continuously or heavily during the seeding year. Even mowing the first year is likely to be detrimental, especially in late August or early September.

If grazing is very light or is prevented entirely during the seeding year, sweet clover can be expected to give high yields the second year as well as in succeeding years, as long as management is provided to assure reseeding and the building of adequate root reserves.

Present experiences indicate that properly managed sweet clover is likely to shade out most of the white clover, birdsfoot trefoil, or annual lespedeza that is seeded with it. Therefore it seems doubtful whether sweet clover should be included in pasture mixtures where the aim is to develop short grass pasture with the low-growing legumes. If sweet clover is to be grown for a season or two, the low-growing legumes can be seeded more successfully after the sweet clover has gone.

Birdsfoot trefoil: This perennial legume has been seeded at many locations throughout the state, and, although it has been slow to get started, it is now showing some promise on a variety of sites. The seedlings seem intolerant of shade and are likely to be killed out by such a plant cover as sweet clover. Extremely close grazing, as with sheep, also may kill this legume. There is a rather wide range of grazing conditions, however, that permit birdsfoot trefoil to grow and to spread by seed, which develops on the prostrate branches.

Birdsfoot is long-lived, deep-rooted, and drought-resistant; it will grow under conditions of moderate acidity and of rather low fertility. It seems therefore to offer considerable promise as a pasture plant over a long period of time, even though several years may be required for a stand to become established. On soils that consistently support a heavy growth of white clover it is not likely that birdsfoot trefoil will successfully compete or contribute much to the yield, but on the less favorable sites it will probably find a place.

Annual Lespedezas (Korean and Common): These legumes grow especially well in the southern Ohio River hills section of the state and at low elevations in the Eastern Panhandle. On sites where white clover will thrive, they will make little contributions. But on the drier, hotter, or less fertile sites, annual lespedezas are quite valuable in pasture seedings. Shallow tillage usually provides ample seedbed preparation; in

POVERTY GRASS AND MOSS on poor, hard, shale soil are easy to tear out by shallow tillage. Since these soils are highly drouthy and erodible, tall-growing grasses and legumes should be maintained. Good stands of desirable forage can be produced. Prevention of overgrazing is essential.

fact, considerable lespedeza can often be obtained by merely broadcasting the seed on the surface of old sods in February or March. Even so, tillage gives better and quicker stands.

These legumes should not be grazed closely in the late summer and early fall because grazing is likely to prevent seeding. If major dependence is to be placed on the annual lespedezas, a seeding rate of 15 to 25 pounds per acre should be used. Korean lespedeza makes somewhat more growth than the common type but may not reseed as well under heavy grazing. The fact that the lespedezas make most of their growth in hot, midsummer weather offers an advantage in balancing the pasture program. Annual lespedezas are not suitable for late summer or fall seeding.

Ladino clover: This is a tall-growing white clover adapted to well-managed pastures, especially on moist to wet soils. It is easily established, but for best results it requires rotational grazing. Under usual grazing management it does not persist as well as common white clover. In one comparison in Monongalia County a mixture including Ladino clover yielded 2,900 pounds the first year compared to 2,300 pounds for seeded common white clover and Kentucky bluegrass, but after the first year of heavy grazing the Ladino clover was partly killed, leaving few other clovers. During the second year the common white clover and

bluegrass gave the higher yield. Similarly, in Hancock County a seeding including Ladino clover gave the highest yield of five seedlings during the first year. Three of the other four, however, outyielded the pasture with Ladino the second year after a year of uncontrolled grazing which killed much of the Ladino clover.

Alfalfa: Successful seedlings of this legume have been made after shallow tillage of old pastures at several locations, but alfalfa apparently requires a somewhat more thoroughly prepared seedbed than most of the other legumes.

In pasture seedlings with no grazing control, alfalfa has not seemed worth while. With proper management though, it may be valuable for improving poor pastures as well as for hay. Other trials are being conducted under controlled grazing conditions.

Orchard grass: This grass has been one of the most reliable in the various seedlings both on plowed and on shallow-tilled seedbeds. The orchard grass seedlings have survived rather close grazing in a number of cases and are providing a considerable amount of ground cover and yield through the third and fourth years. Orchard grass has demonstrated greater capacity for growth during hot, dry weather than Kentucky bluegrass and timothy. It is also quick to get started during the seeding year, even approaching ryegrass in early yield. Grazing animals have always eaten the orchard grass readily in these trials. In fact, excessive grazing probably prevents orchard grass from making its maximum yield in many cases.

The bunchy habit of growth has not appeared undesirable in these seedlings, since other grasses and legumes have filled in between the bunches. Under close grazing the orchard grass does not show the bunching as much as in meadows.

Domestic ryegrass: Common ryegrass is a mixture of perennial (English) and annual (Italian) ryegrasses. In pasture seedlings it gives considerable early cover and yield during the seeding year. If the new seeding is to be heavily grazed, the ryegrass apparently makes a valuable contribution to the herbage yield without seriously competing with the more permanent grasses or legumes. If the seeding is to be protected during the first year, the ryegrass may be undesirable because of competition with the other seedlings. Some of the perennial ryegrass remains as a minor species for several years under ordinary grazing conditions.

Kentucky bluegrass: This grass has not contributed a great deal during the first two years when seeded in a mixture with other grasses, but its known adaptation to local pasture conditions and its capacity to spread when soil fertility is high and moisture adequate justify its inclusion in many mixtures. On especially infertile or hot, dry sites there may be little need to include Kentucky bluegrass seed. The most satisfactory stands have been obtained from August or September seedlings, but spring seedlings also have been satisfactory in combination with white clover. Continuous, close grazing does not seem to injure even the young seedlings, and under such grazing conditions it probably gives as high yields as any other common grass.

Redtop: Considerable redtop has appeared in the various seedings, but it is usually a minor species and may not be any more abundant

ROCKS like these make it hard to prepare a seedbed with a disk, but these and old vegetation can be removed with a spring-tooth harrow or cultivator.

on seeded areas than on the unseeded pasture. Many of the poorer pastures of the state have sufficient redtop already established, with the result that seeding following shallow tillage is apparently unnecessary. If there is doubt, however, it is well to include some redtop in almost any pasture mixture. On plowed seedbeds redtop seed should usually be included.

Timothy: The results with this grass have been rather erratic. For pasture seedings there seems to be little justification for considering timothy in preference to orchard grass, which has given more consistent stands on ordinary seedbeds, persists better under grazing, and grows better in midsummer than timothy.

*Smooth brome*grass: This grass so far has given only very small returns where seeded in old pastures. Its use appears limited to meadows and to tall-grass rotation pastures.

Grazing new seedings: On shallow-tilled seedbeds grazing and trampling by animals immediately following seeding has not appeared to be unfavorable to any of the grasses or legumes. In fact, this may have helped assure a stand and to keep down early weed growth. During midsummer or early fall, after a spring seeding, excessive grazing may cause damage, especially with tall-growing species which need to build plenty of root reserve before winter.

Early grazing during the seeding year on normally plowed areas is ordinarily unwise because close grazing and excessive trampling greatly increase the danger of erosion.

Inoculation of Legumes

On poor pastures it is always safest to inoculate all legumes seeded. This may be done either with commercial inoculant or with soil from improved meadows or pastures where the proper legumes are growing vigorously.

Recommended Seed Mixtures

The cheapest pasture seeding which can be depended upon for varied conditions is *two pounds per acre of white clover*. This is especially suited where only moderate shallow tillage is feasible, where continuous close grazing is expected, and where sufficient bluegrass is present to spread and form a desirable grass sod. Kentucky bluegrass seed should be added at 6 to 10 pounds per acre if its presence is doubtful. Late summer or fall seedings of bluegrass give best results.

An excellent, more diverse mixture which has done well under a variety of grazing and soil conditions is as follows:

	lb. per acre
White clover	1
Alsike clover	3
Birdsfoot trefoil	1
Orchard grass	5
Domestic ryegrass	5
Kentucky bluegrass	3

Various substitutions, omissions, or additions can be made to this mixture to suit the particular conditions. If early grazing is to be light or entirely prevented, it is well to omit the ryegrass. If the soil and site are known to be well suited to white clover and Kentucky bluegrass, and if heavy liming and fertilization are assured, the birdsfoot trefoil may be omitted. If the seedbed is well prepared, and red clover grass grows well in the vicinity, 6 pounds of red clover may be substituted for the alsike clover. At lower elevations annual lespedezas (Korean and common) may be added at 5 to 10 pounds per acre, or, in case the soil is low in fertility and lespedeza is well adapted to the area, 15 to 25 pounds per acre of annual lespedezas (mixed Korean and common preferred) may be substituted for the clovers.

Redtop at 2 to 3 pounds per acre may be added to the mixture under any conditions, but this grass is present in sufficient amount in many poor pastures; hence additional seed is not needed, especially with shallow tillage. If the soil is low in organic matter or contains wet spots, redtop should be seeded unless it is known to be present.

Additional experience may prove that one pound of Ladino clover is more valuable under certain conditions than the three pounds of alsike clover in this mixture. Nevertheless, at present it appears that the alsike clover is a better general recommendation for seeding with common white clover because the alsike makes considerable contribution to the yield without interfering seriously with the stand of common white.

ONE YEAR was all that was needed to produce this excellent stand of white clover and Kentucky bluegrass. A spring-tooth harrow was used in preparing the seedbed. The seeding rate was: white clover, 2 lb. per acre, and Kentucky bluegrass, 10 lb. per acre. The seeding was grazed continuously.

If rotational grazing is to be practiced, the following mixture is promising, especially on moist or wet sites and heavy soils:

	lb. per acre
Ladino white clover	2
Alsike clover	2
Orchard grass	6
Redtop	2

On well-limed sites where management to assure reseeding of the sweet clover is to be provided, the following mixtures seem promising:

	lb. per acre
Sweet clover	10
Alsike clover	3
or	
Red clover	6
Orchard grass	6

A mixture such as this is drought-resistant and does not require high fertility or high soil-organic-matter content. Tall meadow oatgrass may be a valuable addition.

Other mixtures that are used primarily for hay, but which under proper management also may be suitable for grazing, include the various

HIGH YIELDS are received from this stand of orchard grass and white clover when properly managed in a rotational grazing system—especially when mixed with Ladino clover. If the stand is grazed continuously and too closely, however, its yield will become inferior to that of other types of grass.

meadow mixtures recommended for West Virginia (9)—especially the diverse mixtures of alfalfa, clover, and grass. One of the most promising of these mixtures for a variety of conditions is:

	lb. per acre
Alfalfa	10
Ladino clover	1
Orchard grass	5

General Conclusions

Pasture tillage and reseeding is a practice which should be attempted only after consideration of the local conditions and the various factors that are involved. There seem to be two good reasons which may justify pasture reseeding: (1) to obtain quick response to treatment on areas of very poor species composition (2) to introduce new desirable plants that are not present in the native sod.

Reseeding is not a substitute for surface treatment of pastures; in fact, more lime and fertilizer may be used with profit for new seedings than for simple surface treatment. Under proper conditions, reseeding may be highly profitable in the case of continuously grazed pasture as well as in pastures intended for restricted or rotational grazing. The

POOR HILL-LAND PASTURE in Wetzel County is shown. After observing better pastures, the farmer started a new and improved type of seeding.

greatest profit from tillage and reseedling is obtained on soils that have high productive capacity but where the existing herbage is of extremely poor species composition and quality. With soils of high humus content and good water relations, lime and phosphate are ordinarily the limiting factors. Where there are supplied along with tillage and seed of productive herbage, the return is ordinarily large and profitable.

The tillage job should be adequate to assure a stand of the plant species that are being seeded, and the tillage and seeding should be done at the proper season, preferably in the very early spring, when the ground is too wet for ordinary farm work.

Tools are available on most farms to perform the necessary tillage operations. A sharp disk or sharp spring-tooth harrow will usually do a good job in the very early spring, when the ground is moist or wet, unless the surface vegetation is extremely dense. Extra weight is often needed in the case of light horse-drawn tools. Heavy grazing to keep down the vegetative growth or mowing and raking may be necessary to assure a good, shallow tillage job in some cases. Very shallow plowing, with no attempt to turn under all refuse, may be the most practical method of seedbed preparation on sites where other shallow tillage is difficult. Deep plowing is undesirable because it exposes the surface to erosion and turns up soil that is low in organic matter and is therefore undesirable for establishment of seedlings, especially legumes. *Shallow tillage of hill land invariably gives better stands of pasture legumes than ordinary plowing; but plowing gives superior stands of grasses and more complete destruction of inferior grasses or weeds.* If a new seeding is protected from early and excessive grazing there is little danger from erosion on land that is shallow-plowed in contour strips of less than 50 to 75 feet width and on slopes of less than 30 per cent, except in the case of extremely erodible soils. Shallow tillage with disk, harrow, or

cultivator ordinarily provides sufficient protection against erosion except on critical areas, where special protection from grazing is necessary.

If from 50 to 75 per cent of the old vegetation can be torn loose by shallow tillage, reasonably good stands of white clover, Ladino clover, alsike clover, and lespedeza are assured from early spring or late summer seedings. The only exception is lespedeza; it requires spring seeding only for good stands. Seventy-five per cent or more of the old vegetation must be torn loose to assure stands of alfalfa, red clover, and most grasses. Grasses which have given the most consistent stands are orchard grass, domestic ryegrass, redtop, and Kentucky bluegrass.

Under favorable conditions, reseeding can be depended upon to give increased yields of herbage for at least two years, but the greatest and most consistent result is a rapid improvement in herbage quality and protein content. Higher total forage yields are to be expected in cases where tall-growing legumes and grasses are managed as tall-grass pasture (1, 2, 5, 6).

One excellent place to try reseeding is on pasture that has recently been surface-treated and has failed to show the desired response. Soil testing, additional treatment where needed, and reseeding will usually give excellent results. It is well to start hillside reseeding on a small scale and, if the results are satisfactory, to follow up year after year with some additional seeding. Most farmers who have tried reseeding according to recommendations are pleased with the results.

Finally, it is a safe conclusion that proper pasture treatment, tillage, seeding, and grazing management offer progressive farmers an opportunity to prosper under conditions that keep the ordinary farmer at a low subsistence level. The problem is for the progressive farmer to find the right combinations of factors to suit his local conditions and personal preferences.

Part II

PASTURE RENOVATION

Among the trials reported in the previous section, one was conducted on the Reymann Memorial Farms in Capon Valley near Wardensville. The results of this trial were so favorable that it was decided to test the practicability of pasture renovation on a large scale. The renovation was started at Reymann Memorial Farms late in February 1946.

Plan and Procedure

A pasture area of sixty acres was selected for this demonstration. Forty acres were renovated, fifteen acres were left for comparison, and five acres were not used because they were too steep to be tilled. The soil on the area was largely Litz silt loam with some Ashby shaly loam in certain areas. Much of the area was severely eroded and only sparsely

covered with vegetation. This vegetation consisted of briars, poverty grass, weeds, cedars, and Virginia pine. Earlier, small plot trials showed that top-dressing with lime and fertilizer gave only slight increases in yield.

As far as could be determined from information given by long-time residents of adjoining farms, the entire area had been cultivated in the past. Previous to the start of this demonstration the area had been abandoned for cropping purposes and was used as permanent pasture. No treatment had been applied since the area had been in pasture, and its carrying capacity was very low. In fact, the rated carrying capacity of this area in 1945 was as low as one animal to twenty acres, and even at this rate of pasturing it could not be grazed for more than four to six weeks during the summer.

TREATMENT

Preparation of Seedbed

Bushes and small trees were cut and placed in the deeper gullies on the area. Patches of blackberry canes were clipped and left on the soil.

The next problem was to find an implement suitable for preparing the soil for a seedbed. A 1260-pound disc harrow was first tried but failed to produce the desired results. Plows were then resorted to and found to be satisfactory.

Tractor plows set to cut to a depth of three to four inches proved to be effective for breaking the soil surface and covering a part of the trash. Following plowing, the area was double disced. The resulting seedbed was rather rough but was smooth enough to permit the use of a grain drill. However, the rough condition of the seedbed and the fact that plowing and discing was done on the contour aided in the prevention of further erosion. Preparation of the seedbed was started the last week in February 1946 and completed within a week.

Lime and Fertilizer Application

Results of tests on soil samples obtained from different parts of the area indicated that the soil had a pH range from 5.3 to 7.5. Since it was not practicable to define accurately and treat only the areas low in pH, ground limestone was applied to the entire area at the rate of two tons per acre. The lime was spread, following discing, by the use of a truck equipped with a lime spreading attachment.

Fertilizer was applied at the time of seeding at a rate of 500 pounds of 4-12-4 per acre. No additional application of fertilizer were made until April 1949 when 500 pounds of 3-12-6 per acre was applied by use of a truck equipped with a lime spreading attachment.

Seeding

The following mixture of seeds was used and applied at the indicated rate.

COMPARE THESE TWO plots. This is a good contrast of a renovated area and an unrenovated area in the same pasture. Orchard grass and alfalfa, right, grow well on this Litz soil. Cactus is common to the region.

	lb. per acre
Ladino Clover	1
Alsike Clover	3
Alfalfa (Kansas)	5
Orchard Grass	5
Brome Grass (Southern Type)	5
Rye Grass	1.5
Sweet Clover (Yellow)	3
Oats (Clipped)	.60

An ordinary disc grain drill was used for the seeding. The bulky grass seeds were mixed with oats, which was included in the mixture merely to facilitate the passage of the grass seeds through the drill. The legume seeds, which had been inoculated, were mixed together and passed through the grass seed hopper on the drill. The operation of seeding was carried out immediately following the spreading of lime and was completed on March 3, 1946.

COST OF TREATMENT

To determine the practicability of reclaiming eroded, rolling land for pasture purposes, an accurate record was kept of the labor, use of equipment, and materials necessary to perform the operation of renovating an area of forty acres.

It is realized that the cost of reclaiming land for pasture will vary widely depending on the location, freight rates, cost of local farm labor, machinery available, and the condition of the area to be renovated. It is believed, however, that the data which follows will aid farmers in

estimating the cost of reclaiming abandoned land for pasture purposes in their respective localities.

Experimental Results

There are various ways of measuring or evaluating the results obtained from experimental work or demonstrations, but it is often rather difficult to express these results in terms which can be readily applied on a practical basis. Most farmers estimate the value of pasture by the animal units it will carry; therefore, this method was used in measuring the results obtained from this demonstration.

Beef cattle and sheep were grazed on the pasture during the pasture seasons of 1946 to 1949 inclusive. Each beef animal was considered as one animal unit and five sheep were considered as being equal to an animal unit. A charge of \$2.00 to \$2.50 per animal unit per month is usually made for pasturing livestock in this section, so, in computing the cash value of the returns from this demonstration a figure of \$2.00 per animal unit per month was used. The value of the hay made from the pasture area was based on a price of \$20.00 per ton. Oats threshed from the area in 1946 was given a value of \$1.00 per bushel.

RETURNS FROM THE DEMONSTRATION

It was not expected that any returns in the form of pasture or hay would be derived from the renovated area during the first summer following seeding. Nevertheless, as the season progressed, it was observed that the oats was making an unexpectedly heavy growth which might endanger the stand of pasture plants. Clipping of the area was considered, but was not deemed advisable. Such a close cutting at this time would have injured the stand of legumes and grasses. It was finally decided to remove the oats by the use of a combine adjusted to cut the oat stems just below the grain heads. Following combining, the straw was removed from the area with a pick-up baler.

An extended dry spell during the fall of the first year after seeding of the renovated area, caused an acute shortage of late pasture in this locality. In view of the fact that the pasture seedlings had made a good growth following removal of the oats, it was decided to utilize some of the much needed green forage. Accordingly, the area was pastured at the rate of one animal unit per acre from September 15 to October 31.

In 1947 the demonstration area was pastured continuously from April 3 to September 5 at the rate of one animal unit per acre. It is recognized that this number of animal units on the area for a period of five months represented severe treatment for a recently renovated pasture. But 1947 proved to be a very poor season for pasture growth and it was necessary to utilize every bit of available pasture in order to maintain the livestock population. Because of late rains the pasture made a good recovery from the heavy grazing and was in good condition to withstand the winter.

TABLE 7. AVERAGE PER-ACRE COSTS OF RENOVATION

LABOR AND MATERIALS	MAN HOURS	MACHINERY HOURS	COST*
Removing Brush and Briars	2.5	.5	2.00
Plowing	2.2	2.2	4.40
Preparing Seedbed	.8	.8	1.60
Seeding	1.2	1.2	2.40
2 Tons Ground Limestone (applied to land)† .....	....	....	5.00
500 lbs. 4-12-4 Fertilizer‡ .....	....	....	9.38
500 lbs. 3-12-6 Fertilizer§ .....	....	....	8.00
Seeds .....	....	....	11.46
Totals	6.7	4.7	44.24

* Based on a rate of \$1.50 per hour for the use of machinery and \$.50 per hour for labor.

† Obtained at a nearby quarry at a cost of \$2.50 per ton delivered to the farm and spread on the field.

‡ Based on a rate of \$37.50 per ton delivered to the farm.

§ Based on a rate of \$32.00 per ton (April 1949).

There was a good growing season during 1948 and the pasture made excellent early growth. An average of three-fourths of a ton of hay per acre was harvested from the demonstration area in June. On August 1, beef cows were placed on the area at the rate of one animal unit per acre and allowed to remain until September 15. On October 1, sheep were turned into the area at the rate of one-half animal unit per acre and allowed to remain until December 3.

On April 3, 1949, an application of 500 pounds of 3-12-6 fertilizer was made on the area.

In June 1949, one and one-fourth tons of hay per acre was harvested from the area. A second cutting of hay, removed the last of August 1949, produced another ton per acre. On October 12, one animal unit of beef cattle per acre and one-fourth animal unit of sheep per acre were turned into the area and allowed to graze until December 6.

COST STUDIES

In any enterprise it is desirable to determine if an operation has been profitable. The cost of reclaiming the forty-acre area for pasture purposes has been computed in dollars and cents and is shown in Table 7. An attempt to express the returns is shown in Table 8.

This comparison of costs with returns shows that the value of crops produced was \$66.76 per acre over and above the cost of treatment during the four-year period.

An additional item which must be taken into consideration when estimating the returns derived from pasture improvement operations, and one which is very difficult to evaluate, is the continued increased productivity and the overall increase in land value.

CLIMATIC CONDITIONS

One of the limiting factors in the production of crops and pastures in this section of West Virginia is insufficient moisture. According to the United States Weather Bureau, the average annual precipitation in

TABLE 8. CASH VALUES OF RETURNS PER ACRE FROM RENOVATED PASTURE

YEAR	RETURNS	CASH VALUE
1946	28 bushels Oats @ 1.00	\$ 28.00
	1 Animal Unit per A for 1½ mo. (Cattle) @ 2.00	3.00
1947	1 Animal Unit per A. for 5 mo. (Cattle) @ 2.00	10.00
1948	1500 lb. Hay per A @ 20.00 per ton	15.00
	½ Animal Unit per A for 2 mo. (Sheep) @ 2.00	2.00
	1 Animal Unit per A for 1½ mo. (Cattle) @ 2.00	3.00
1949	2¼ Tons Hay per A @ 20.00 per ton	45.00
	1 Animal Unit per A for 2 mo. (Cattle) @ 2.00	4.00
	¼ Animal Unit per A for 2 mo. (Sheep) @ 2.00	1.00
TOTAL RETURNS IN FORM OF CASH VALUE		\$111.00

this area is 30.36 inches which is considerably less than in most sections of the State. Frequently the summer rainfall occurs as heavy rains with relatively long dry periods. This greatly reduces pasture growth.

In 1946 the rainfall was above normal during the early part of the growing season and below normal in September and October. The favorable weather during the early part of the season allowed the young pasture plants to become firmly established.

Rainfall for 1947 was below average during most of the growing season. Furthermore, the precipitation which did occur during the growing season was poorly distributed. It occurred in infrequent hard rains leaving long periods of dry weather during which pastures suffered severely.

Rainfall for this area was above average and well distributed for the years 1948 and 1949. This resulted in unusually good growing seasons and no doubt accounts in part for the excellent production received from the demonstration area during these years.

Conclusion

It is believed that the results of this demonstration clearly indicate the practicability of renovating worn out pasture land and applying results obtained on small experimental plots to larger areas.

TABLE 9. PRECIPITATION ON REYMANN MEMORIAL FARMS

MONTH	YEAR				AVERAGE 1946-1949	NORMAL
	1946	1947	1948	1949		
	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)
May.....	4.15	2.55	3.75	4.61	3.76	2.96
June.....	4.08	1.82	3.34	8.33	4.39	3.00
July.....	2.78	2.92	3.74	3.95	3.34	3.10
August.....	3.76	4.50	6.14	4.70	4.77	3.63
September.....	1.32	1.82	2.62	1.55	1.82	2.59
October.....	2.95	1.05	4.92	3.56	3.12	3.16
TOTAL.....	27.32	26.06	42.48	37.80	33.41	30.36

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