

THESIS  
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To study the available literature on pasture and meadow management.

(1) Literature will be reviewed.

(2) "PASTURE AND MEADOW MANAGEMENT"

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(3) Following points will be studied:

Submitted to

Prof. T. B. Hutcheson, Head of the Agronomy Department

Virginia Polytechnic Institute

as a Minor Thesis

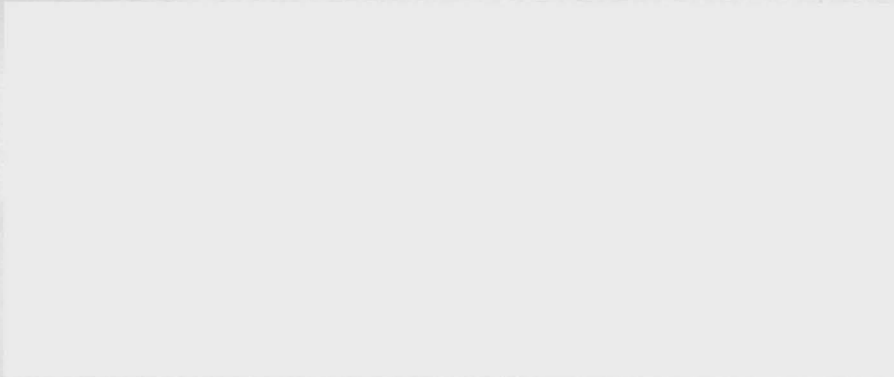
to satisfy in part, the requirements for the

Master Degree in Agriculture

VIRGINIA POLYTECHNIC INSTITUTE  
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Submitted by  
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T. E. Burke,

November , 1922.



PROPOSED PROJECT TO SATISFY REQUIREMENTS FOR  
MINOR IN AGRONOMY FOR T. E. BURKE.

- SUBJECT: Pasture and Meadow Management.
- OBJECT: To study the available literature on pastures and meadows.
- PROCEDURE: (1) Literature will be reviewed.
- (2) Results will be reported in the form of a thesis.
- (3) Following points will be studied:
- A. Importance of Pastures.
  - B. Classification of Pastures.
  - C. Cultural Methods.
  - D. Seeding Pastures.
  - E. Carrying Capacity of Pastures.
  - F. The Leading Pasture Grasses.
  - G. Use and Purpose of Meadows as Distinguished from Pastures.
  - H. Meadow Mixtures.
  - I. Cultural Methods.
  - J. Fertilizers for Meadows.
  - K. Conclusions as to the Management of Meadows and Pastures.

SOURCE OF INFORMATION.

The object of this thesis is not to report actual research work done, as time and facilities did not permit, but is to make a report of the available literature that could be obtained on the subject.

At the beginning it was found that very little work had been done along these lines by either the United States Department of Agriculture or the Agricultural Experiment Stations of the various States. In the Agricultural Library were found Farmer's Bulletins, Department Bulletins and Circulars of the United States Department of Agriculture, Year Book Reports and State Bulletins bearing on the subject of pastures and meadows. Letters written to the Directors of all the State Experiment Stations brought in every case a courteous reply and often recent bulletins that the Library had not received. Books of all kinds that touched upon the subject were freely consulted.

In the West the United States Forestry Service has given some attention to pasturage on the National Forest Ranges. A few experiments of pastures and meadows have been carried on in the East. Everywhere efficient pasture and meadow management is recognized as profitable and farmers are urged to give more attention to this important phase of farm management. At the same time it is realized that there is a lack of experimental data and it is recommended that additional research be done to determine the best method of pasture and meadow management of different climatic and soil conditions.

## IMPORTANCE OF PASTURES.

The importance of proper care and management of the vast acreage of pasture lands in the United States has only in recent years been realized.<sup>(23)</sup> With the increase of production of livestock of all kinds the once abundant growth of native forage plants has been reduced and in many cases the pastures left almost bare. Now that the importance of pasturage is being forced upon livestock men, more especially cattle and sheep growers, it behooves them to take steps to restore and maintain their pastures in their former state of excellence.

In the United States there are 878,798,325 acres of farm land.<sup>(22)</sup> 318,518,917 acres are in crops and 291,439,515 acres are in pasture. Or, of all the land devoted to farming 36.2% grows crops, and 33.2% is in pasturage. Of this, 9.6% is in a state of improvement, 11.2% is woodland and other pastures classed as "unimproved" occupy 12.4%.

These statistics from the 1910 Census show that for every 100 acres of land in crops in the United States, there are 91.5 acres in pasture. In Virginia a larger area is devoted to pasturage. For every 100 acres in crops there are 98.1 acres in pasture.

It appears from these figures that one half of the farm land of the country is being practically neglected. The reason for this is that crops have been grown extensively for a long time and the soil has long since become exhausted for plant food; disease and pests are present, and vitality is lowered. All of these factors tended to reduce crops. It was only natural that steps should be taken to remedy such conditions. This was done, while pastures in no way harmed by the light grazing they were subjected to, flourished. Conditions have changed. Where one steer once ranged, there are now ten. It is

only natural that the pasture lands should deteriorate under such care, or rather lack of care.

So pastures are now beginning to receive the attention of the owners as crops did decades ago, and the old adage that "necessity is the mother of invention" may be quoted as the reason for this.

In England, one-half of the tilled land is in pasture.<sup>(49)</sup> For 45 years the acreage of permanent pastures has increased annually about 1%. The last Census of the United States reports our hay crop to be 61,000,000 tons per year. There are no statistics to show the percentage that comes from pastures but it is considerable. The combined value of the hay and pasture grasses far exceeds any other crop except corn. This hay crop would sustain all the livestock of this country for three months.

## CLASSIFICATION OF PASTURES.

Pastures may be divided into two main groups, e.g.

1. Permanent pastures.
2. Temporary pastures.

Of these groups the former is by far the type that needs most attention at the present time. The temporary pasture comes in the regular rotation of crops and belongs to the cropping system of farming. However, it gives good grazing and is to be given every consideration, being as much a true pasture as the range lands of the West.

A temporary pasture may be classed as an improved pasture. According to the United States Bureau of Census, in 1909 there were about (22) 292,000,000 acres of pasturage in this country. Of this about 208,000,000 acres are unimproved, leaving approximately 84,000,000 acres of improved pasture land, the majority of which is found in regular crop rotation, and is therefore, a temporary pasture. This shows that there is approximately one-third the acreage in temporary pasture that is in permanent pasture.

The <sup>un</sup>improved pastures of the country aggregate a total acreage of more than any other type. By <sup>un</sup>improved pastures we understand a natural growth of native plants to which no pasture management has been applied and where no fence enclosures have been erected. The unfenced western ranges are typical examples of the unimproved pasture.

A pasture which is just coming under the proper management, or one which has been fenced preparatory to good care is called a semi-improved pasture. (17) The great area of logged-off lands, not cleared but fenced, and producing some grass for livestock comes under this class. It is still subject to fires, and the undergrowth has to be continually fought, otherwise it would soon become dense and shade out the grass.

The improved pasture is the type usually found on land that could just as well produce good crops. Often it is a part of the regular rotation and is, therefore, a temporary pasture. It is in a high state of management and receives all of the attention of any farm crop. This type of pasture is usually provided to furnish early needs of the stock and are short in duration. Such a pasture is made up chiefly of annual plants, of which there are many. Soil and climatic conditions as well as the type of animal to be pastured will determine the species to be used. (49)

### CULTURAL METHODS.

Very little experimental work has been done to determine the best cultural methods to apply to pastures. That they need attention is well known, but the method is something that has been neglected in this country. In England, where the areas devoted to any method of farming are small, pasture culture has received much attention.

For the different types of pastures there are different methods of maintenance. On the open ranged the areas are so large that only superficial attention can be given the individual demands. A system (23) that is best for the total area must be used. Overgrazing, premature grazing in the spring, and the poor distribution of watering places are in a great measure responsible for the deterioration of the native pastures of the western United States.

The old stockmen do not seem to realize that their once unlimited area of grass from one to three feet in height has been limited by fences, and that continual grazing has lowered the vitality of the best native grasses, while the less desirable ones have been unmolested and have flourished. When the best grass is gone the animals finally eat the less desirable until at last only weeds remain. This is a certain outcome of overgrazing. If the plant is continually nibbled off at the surface as soon as growth begins, it will soon die. The part above the ground gains vigor from the air and sunlight, in the absence of which no plant will grow.

Premature grazing has much the same effect as overgrazing. If the plants do not get a good start in the spring, they are handicapped the whole growing season. By grazing too soon many are killed outright while others never have the chance to reach more than half growth. Often by waiting a week longer before turning the cattle on a pasture sufficient growth will have taken place to insure a good growth the



whole season provided the proper care is given.

Too few watering places tend to cause overgrazing and tramping in their immediate vicinity. At one watering place in Texas the result of overgrazing and tramping was plainly noticeable in a radius of six miles of the watering place. Saying that one-half of the grazing quality of this area was destroyed, and allowing 100 acres per head the area necessary to graze almost 400 cattle a whole season would be destroyed.

It is a great temptation to overstock, but the far-sighted stockmen can readily see that the proper care of a pasture now will save him money in the years to come. By carefully observing the growth of pasturage in the spring the proper time to begin grazing may be determined. The time of greatest vegetation consistent with the profitable handling of the stock is when the date and number of head per acre can be determined. Great care should be taken in this estimate, it being far more desirable to understock, rather than even slightly overstock. The number and proper distribution of watering places should receive careful attention.

The owner who has only to maintain his pasture is indeed fortunate compared with the one whose fields are so far gone as to be almost useless for grazing.

When a pasture has lost its feeding value, it is usually almost bare of good forage plants and very heavily weeded. To improve these conditions the land must be reseeded and the weeds eradicated. When the area is not very large the best method of removing the weeds is to cut them before they make seed. On the open range this is impossible due to the large area to be covered. Sheep are sometimes employed for this purpose.

To reseed these large areas artificially would be impractical. (26)

Therefore, Nature must be employed. First of all the native forage plants must be studied; their needs and requirements must be found out and supplied as nearly as possible.

In rebuilding the pasture avoid grazing on wet ground, especially early in the spring when the principal forage plants are beginning to grow. At this time they are very weak, and any tramping into soft wet ground will injure them and cause retarded growth.

When there is any doubt about the carrying capacity of pastures, limit the number of stock that the given area will support in good condition as feeders.

Deferred grazing is perhaps the best method yet devised to build(26) up depleted ranges. Observations have shown that one-fourth of the growing season remains after the plants have matured seed. Therefore, an area one-fourth the carrying capacity allotted to the animals to be grazed is protected from all grazing until after seed maturity. After the seed has formed the area is heavily grazed. This is done to knock off the seed and cause them to be tramped into the ground. Here germination takes place readily and there is a better supply of moisture than on the surface. The second year there will be a good growth of the new grass. If conditions are favorable, the area should be grazed moderately the second year. However, if conditions are not favorable, then the area should be protected for three or even four years before another area is treated in a like manner. As soon as conditions justify, normal grazing is resumed.

With this system of grazing, it is well to use sheep if possible as they help to get rid of the weeds and tramp the seed into the ground better than cattle. This principle of deferred grazing is perhaps the best that can be applied to the great pasture lands of the West.

If the stockmen will work for open quiet grazing, evenly distributed over entire areas to be grazed, and will observe closely the condi-

tion of the pasture and increase or diminish the head of stock in order to obtain the maximum growth of the forage plant, the ranges will not become run down and the grazing industry will become a permanent profitable one, instead of a gradually losing one.

Another pasture type that is being increased yearly is the cut-over or logged-off lands of the country. <sup>(17) (31)</sup> The modern method of logging leaves a large amount of the debris in which fires are very likely to break out during dry seasons. It is a common practice to burn over these logged-off areas at a time when the fire may be controlled so that the standing timber may be protected from uncontrolled fires in the future.

The best time to reduce this second growth and debris to ashes is when it is very dry. In order to eliminate the chance of the undergrowth surviving the fire, it is sometimes advisable to slash the growth that comes on after logging. In September, before the fall rains start is an excellent time to begin burning. Great care must be taken, however. The slashing should be done in the early summer when the sap is flowing and when the leaves are out. The roots will die easily at this time. By cutting up the large limbs and splitting with dynamite the decayed logs, the work of the fire will be made more complete. When burning follows immediately after logging, it is very doubtful whether the practice of slashing is profitable.

In the Piney Woods region of the south, even in the virgin tim-(17)ber lands there is a growth of native grasses. Due to so much shade, the carpet of pine needles, and the fact that it is burned over so often this growth is of no value, being stunted too much to reach any amount of growth. With the clearing of the land, however, these grasses make abundant growth.

The native pasture grasses are wire grass, broom sedge, carpet grass, Japan clover, "switch" or reed cane, maiden or blue cane, hop clover

and Bermuda grass.

In the regions where native grasses abound it is very doubtful if burning is ever beneficial except immediately after logging to add humus to the ground in the form of decayed wood and ashes, and to clear the land of undergrowth. Burning does not increase a pasture or make it mature earlier in the Spring. It does tend to kill out the desirable plants, however, and really retards growth in the early Spring. Cattle prefer burnt over pasture because they do not have to pick the new growth out of the bed of the winter killed grass. The carrying capacity of a pasture is lowered by burning.

By annually destroying vegetation before the organic matter becomes mixed with the soil to form humus there is a great loss in fertilization. These soils are lacking in humus and its absence means a heavy annual loss.

Such fires also tend to inhibit the desirable carpet grass and Japan clover while the undesirable wire grass and broom sedge are little effected.

If the practice of firing annually could be changed to burning occasionally to control the wire grass and check the growth of underbrush, it would be a great step toward improving this type of pasture.

In different sections of the country there are different conditions and each logged-off land intended for pasture has wants of its (31) own. In Oregon and Washington yearly burning is not practiced. After logging the area is fenced and burned as completely as possible. There are no native grasses found that would furnish pasturage. Weeds alone are found growing voluntarily. The ashes that cover the ground after burning form an ideal seed bed. Rains follow burning very closely and insure the seeds a good start. The seeds used under different conditions will be taken up under a later heading.

If the land has been burned over during late summer or early fall, the seed should be sown before the ashes have had time to be settled by the fall rains. In the loose ashes the seed will be covered by the first rain and good germination usually follows. If burning is as late as October, sow only the grasses and wait until early Spring for the clover seeding. The clover is very susceptible to cold and cannot withstand the winter freezing.

Because of the amount of money invested and the difficulty of renewing or improving this type of pasture, the best care and management known should be given it. Close grazing is very bad practice for two reasons:

1. Stock do very poorly on scant food unless very thrifty.
2. Close grazing lessens the quality of food produced and shortens the life of the pasture.

A good start is very necessary for a new pasture. If seeded in the fall, never graze before late spring the following season. Observation alone will determine the date to begin grazing. The result (26) of experience shows that pastures may be most successfully managed when they are fenced and divided into several fields. By shifting the stock from field to field the grass is given a better chance, being protected at the time it needs the rest most. This is known as the rotated method of pasture management and is much used in the West.

On the new pasture land second growth is continually appearing. If not controlled in a few years it will shade out the grasses. Angora goats feed largely on browse and are especially adapted to keeping down growth of underbrush on logged-off pasture lands. As the goats cannot consume all of the forage produced, cattle also should be pastured to take care of the grass that the goats do not use.

In the Eastern states and throughout the corn belt, pastures may be placed under the following heads:

1. Virgin pasture lands.
2. Exhausted farm lands.
3. Bluegrass pastures.

The first and last type are in most cases permanent, while the second may be temporary pasture.

The virgin pasture lands are usually in pasture through necessity. They are in such a condition that cultivated farming is impossible. These lands are either too wet, too stoney, too steep or too stumpy to farm. (7)

The wet lands require drainage; otherwise they are of little value for anything except to furnish a breeding place for mosquitos and flies. If properly drained, however, they furnish excellent pasturage.

The steep hillsides are usually poor. Even on such soils a fairly good growth of native grasses and clovers are found. By the addition of a little lime the clover may be caused to flourish and crowd out many undesirable weeds and ferns that tend to reduce the quality of the pasture. (16)

Neither stones nor stumps are desirable and both should be removed whenever possible. If the stumps are allowed to decay some humus is added to the soil. It is more economical to get them out of the way and allow grass to take their place, however.

The exhausted farm lands cover a large percentage of the pasture lands of the eastern United States. When the early settlers began to clear the lands of this country, they found that wherever timber was cut, an abundance of native grasses and clovers spring up without seeding. This land was usually pastured for 15-20 years while the stumps rotted and disappeared, and while other areas were being cleared. Finally, when the pastures became somewhat exhausted, the land was plowed and kept in grain for a number of years. When the grain was no longer a profitable crop, grass was sown. When the grass no longer

gave good results, the exhausted land was converted into a pasture again. With such a history it is no wonder that these lands which have been drained of their plant food are in such poor condition.

In the past fifty years many remedies have been suggested for improving these old pastures. Three (7) have gained some support:

1. Reseeding.
2. Controlled grazing.
3. Harrowing.

Professor G. P. Roberts of the New York College of Agriculture advocated reseeded forty years ago.

Recent experiments have shown, however, that even if the seeds germinate, they make little growth. The native grasses can reseed themselves. The problem is to make the land productive enough to support the grass seed.

Restricted grazing has sometimes been recommended to improve worn out pastures. By allowing rest periods, or holding off the stock until a good growth is made in the spring, some pastures have been improved. On bluegrass this latter method is especially recommended.

Harrowing was advocated in England a century ago. In this country harrowing alone has given no apparently good results. With seed, lime, or fertilizer, it is a good practice as it tends to work them into the soil where they are most needed, and where they give the best results.

Lime and acid phosphate are necessary to practically every old pasture land in the East before a good sod can be obtained. The addition of these elements of plant food to the worn out soils promote the development of clovers, which in turn improve the soil by adding available nitrogen and humus. Good pasture grasses will follow a good growth of clover. White clover is one of the best improvers and will cause pasture improvement as well.

Often the application of lime will cause the growth of clovers. Barnyard manure is very valuable but few farmers can afford to use it on their pastures.

The Delaware Experiment Station (15) has carried on fertilizer experiments covering a period of ten years. The nature of the pasture or meadow under consideration in all cases determines the treatment to be applied. For the production of clover the following application per acre was found best:

125-300 pounds of acid phosphate.

50-100 pounds of muriate of potash.

Where bluegrass was to be stimulated, 100 pounds or less of nitrate of soda, applied with the above as a top dressing gave the best results.

As a result of grazing experiments carried on at the same time it was found that over grazing tended to reduce the best pasturage and leave undesirable weeds. On the other hand, it was noted on the lightly grazed areas there was a rank growth of grass, and the sod soon became weakened. The heavily grazed fields were freer from weeds and had a more even turf. Light grazing, therefore, is as dangerous as over-grazing. This sustained results reported at the Virginia Experiment Station ten years previous (3).

F. W. Taylor, Dean of Agriculture at the New Hampshire College, gives some interesting information on the management of pastures in his State. (42).

Too early and too late grazing are to be avoided.

Set fire to the junipers in early Spring and later cut out. Cut the alders, birches, choke berries and other bushes and burn them in the Spring and Fall. This gives the sunlight a chance to reach the grass.

On an area cleared as above the ground was plowed and harrowed thoroughly and reseeded. The average yield of green grass per acre



for four years was 3309 pounds. On the check, where no treatment had been applied, the average yield for five years was 1311 pounds. This increase of a ton per acre is worthy of consideration. Plowing is possible only on comparatively smooth land.

Lime tends to eradicate moss from pasture fields.

In Scotland the application of 1000 pounds of basic slag and 800 pounds of kainit per acre doubled the yields of grass. Due to soil and climatic conditions such a treatment shows little results in this country.

In connection with seasonable rains nitrogen in some readily available form, such as nitrate of soda or ammonium sulphate, is the only top dressing which will give a reasonable and economic return.

"Frequent reseeding, together with light annual top dressing with some nitrogenous material, is about the only treatment for our very rough stony pastures".

"By scattering 10-15 pounds per acre of a good mixture of pasture grass seed over the ground the latter part of March or just as the frost is coming out and permitting the seeds to be covered by the Spring rains and the alternate freezing and thawing of the surface soil, and then applying 100-150 pounds of nitrate of soda or sulphate of ammonia per acre about the first day of May, a decided improvement of the pasture will in most cases result." F. W. Taylow. (42)

The New York Extension Service gives some interesting and valuable insights as to pasture culture in New York State. (7)

It is not common practice to plow an old pasture when improving it, but in many cases this treatment is better in every respect than top dressing.

When good pasture grasses are present, a top dressing of lime and acid phosphate will restore the pasture in three or four years. As the lime dissolves and penetrates slowly, at least three years are re-

quired to take up the lime when applied as a top dressing, while if the ground was plowed and the lime harrowed in, one year would accomplish the same results. It is a question whether the full benefit of the lime will ever be reached when applied as a top dressing. It gives good results, however, and is in constant use.

When a top dressing is applied to a steep hillside which is sparsely covered with vegetation, a hard rain may carry off most of its value. On such land apply the dressing in early summer after some vegetation has appeared.

Plowing destroys the weeds at once, and mixes the lime and acid phosphate with the soil where they become effective immediately. On poor weedy land plowing is the best method.

The following practice is recommended:

"1. Plow late in the fall. Old pasture land can be plowed when the soil is so wet that the other fields cannot be worked."

"2. Put on lime (1 ton per acre) and acid phosphate (200 pounds per acre) either just before plowing or the following spring."

"3. Sow a crop of oats and seed down, rolling the land well if it is loose."

"4. To favor the grass, harvest the oats for hay if the season is dry."

"5. The next year a crop of hay may be harvested, or pastured rather lightly. Experienced farmers say that it is better to cut hay for one year, as this gives a good chance for the growth of clover, and a better pasture will follow. Moreover, a good hay crop will also largely pay for the cost of labor and fertilizer."

"After this, there should be a good permanent pasture for a long period of years". (7)

In England, where pasture experiments have been conducted many

years, it is recommended that a light top dressing of 1000 pounds of lime and 200 pounds of acid phosphate be applied every five years on permanent pastures. This application will keep white clover in the pasture which not only increases the carrying capacity, but also improves the grass.

Harrowing in some cases gives as good results as plowing old pastures. A spring-tooth harrow will stir the soil to a depth of three inches, tear out moss and weeds, but will do very little damage to any good grass and is an excellent practice to invigorate the sod.

Lime and acid phosphate should be applied before harrowing and the seed afterwards.

Pennsylvania has perhaps done more than any other state along pasture lines as they apply directly to eastern conditions. This Station (13) has shown to farmers that pastures need plant food just as much as a cultivated crop does. Farmers fail to realize that for every 1000 pounds of meat and every 10,000 pounds of milk made on grass, there is carried off the equivalent of 100 pounds of 16% acid phosphate, large amounts of lime and nitrogen and potash. Young animals make an especial drain on the plant food because their bones require large amounts of lime and phosphorous.

Bluegrass and white clover will grow on soils lacking in lime. They will not grow on soils that are both poor and acid. On such soils lime may be considered the foundation of improvement work. Two tons of ground limestone or its equivalent is recommended. The caustic form seems to kill moss and is largely used for that purpose.

A top dressing of 300-400 pounds of acid phosphate in connection with lime has been known to bring a solid stand of white clover in one year on an impoverished hillside. Lime or phosphorous alone gives

negligible results. Phosphorous alone on manure shows some increase in yield. Basic slag is good, but priced too high. Bone is excellent grass fertilizer, and if not over 50% higher than acid phosphate, can be profitably used.

Nitrogen is too expensive and short lived a fertilizer on pastures except to stimulate new seedlings on poor soil in the absence of manure. Most soils have large amounts of potash. Until the price of this element is materially reduced, its application to pastures is not advisable.

Manure is always good on any soil. On pastures even as light an application as four tons per acre gave good results. The manure left by grazing stock is of little value, even when the animals have consumed feed other than pasturage. Their droppings are usually along a stream or under a shade tree. The solid manure dropped on the grass promotes a rank unpalatable growth. Harrowing to scatter these droppings is recommended but seldom practiced. Summer manure which must be gotten away from the buildings may profitably be applied to pastures when no tilled land is available. By scattering 50-75 pounds of acid phosphate over each load the pasture may be doubly improved. Where a system of dairy farming is used this is a very satisfactory arrangement.

Where a pasture has become poor or full of weeds, plowing, if practical, is advisable. Two methods are in common practice:

- (I)
  1. Plow.
  2. Work down thoroughly.
  3. Fertilize.
  4. Reseed in Spring or in August.
  
- (II)
  1. Plow.
  2. Corn on old sod (manured) - part of lime and fertilizer on corn.
  3. Following spring sow pasture mixture with light seeding of oats or barley. (6 pecks).

At this time apply bulk of lime after plowing, with 300-400 pounds of acid phosphate and manure or a complete fertilizer. By plowing twice

the sod containing the little humus in the soil is brought near the surface where it is needed.

Once the pasture is started do not graze too soon. Better cut for grass one or two seasons, and let the grass get a start.

A pasture not too deteriorated may be renovated without plowing. Very often the conditions encountered make plowing impractical.

Lime and phosphate may be applied at the farmers convenience. Several years will be required to show very marked results.

Very few pastures can be found that have not some growth of bluegrass and white clover. By sowing red, alsike and some sweet clover, a good growth is obtained and much nitrogen is added to the soil. A cover crop may be harvested the first year. The bluegrass and white clover will then come in and make a good growth.

In 1910 the Pennsylvania Station began some fertilizer experiments on grass to determine the botanical composition of a permanent pasture as influenced by fertilizers of different composition. (19) Acid phosphate, sodium nitrate, and potassium chloride were applied alone, and in combinations of two and three, the ingredients varying in ten per cent stages. There were 66 plats laid out in the triangular form of fertilizer experimentation, 50 pounds per acre of acid phosphate, sodium nitrate or potassium chloride were applied annually. The soil was Hagerstown clay loam. (18)

The area used was seeded to grass with wheat in 1906. The following spring clover was seeded. In 1908-09 the field was pastured and the following year the plats laid out and fertilizers applied for the first time. Lime had never been applied.

Botanical composition at beginning of experiment:

Canada Bluegrass.....	50%
Kentucky Bluegrass.....	30%
Timothy, white and red clover.....	20%

Kentucky bluegrass was especially aided and attained prominence in the nitrogen end of the triangle. Very little timothy was found where nitrogen was the chief fertilizer. Potash seemed to stimulate the growth of timothy. Canada bluegrass was found in only two plats at the end of seven years, showing itself to be unsuited to such management as was given this experiment. Nitrogen hindered the growth of the clovers, especially in the case of red clover. An even mixture of potassic and phosphatic fertilizer seemed to be best suited to the growth of white clover. The predominance of potash seemed to be necessary for the best growth of red clover.

The relation between the lime requirement and the different fertilizers is interesting to note. An evenly balanced mixture of all three fertilizers neutralized acidity. Sodium nitrate tends to reduce acidity.

Bluegrass pastures present a problem different from other types of pastures and one that needs very careful attention. In 1908 the Virginia Experiment Station started some experiments on the management of bluegrass pastures. (3) The following summary states briefly the deductions made as a result of five years work.

1. Disking and harrowing of bluegrass sods cannot be recommended fully, as the value of such practice is very doubtful.
2. "Heavy grazing gave 1485 pounds of gain on  $2\frac{1}{2}$  acres of land in three years. Light grazing gave 838 pounds of gain in the same time on an equal area. The heavily grazed field was freer from weeds and had a more even turf at the end of the five years than did the lighter grazed field. More bluegrass pastures are injured by undergrazing than by overgrazing." For finishing fat cattle light grazing is necessary to furnish a sufficient amount of grass. Where broom sedge is found on a bluegrass pasture it is advisable to fence off such areas and graze heavily with young cattle until the sod is improved.

and then use again to finish fat cattle.

3. The value of alternate grazing is very doubtful.

4. These experiments are conducted on a limestone soil and on a bluegrass red top pasture. On a different soil type the results might be different.

There are certain sections of the East where bluegrass has always grown and where seeding has never been necessary. There are some parts of the country (5) where bluegrass must be carefully seeded in order to obtain stands of grass.

On fertile tillable land, sow timothy and bluegrass with wheat in the Fall, adding clover in the Spring. Cut this for two years for hay and then pasture. In the end bluegrass will predominate. The timothy and the clovers are used to furnish a sod the first year as they mature quickly while the bluegrass matures very slowly, taking two or more years to gain maturity.

"When long established bluegrass pastures become unthrifty, the destruction of weeds, the application of stable manure, and the reseeding of the scantest patches, are in average cases, the most practical means known for its improvement." (5)

A bluegrass farm owner in Southwest Virginia (41) suggests this method of improving a pasture that shows signs of deterioration:

Apply 200-300 pounds of acid phosphate per acre. On steep hills, where a large percentage of the pastures are found, before the fertilizer is applied, run a subsoiler ten inches deep and a yard apart, over the field. This will not disturb the sod and will keep the plant food in the fertilizer from being washed away by the first rain. It will cause it to become available quicker also, as it will dissolve in the ground rather than on the surface.

At the Massachusetts Experiment Station (47) (50) Kentucky bluegrass was topdressed annually for five years with nitrate of soda. The

treatment caused rust and was generally unsatisfactory. Another plat topdressed with potash salts and basic slag in addition to nitrate of soda produced better results. Heavy applications of manure and complete fertilizers produced about the same results. Nitrate of soda and muriate of potash had little effect when used alone. Acid phosphate alone gave the best results of any single element. The results of combining all three elements seemed to add to the effectiveness of each.

The bluegrass region is usually referred to as that section of the United States embracing Southwest Virginia, the adjoining portions of West Virginia and Tennessee, the North west central portions of West Virginia, and a large area of central and western Kentucky. (4)

There seems to be a great difference in the fat producing qualities of bluegrass grown in different localities and on different soils in the same locality.

It has been shown by W. B. Ellett, at the Virginia Experiment Station that there is a wide variation in the protein content of Kentucky bluegrass in different localities. (51) The protein in the water free material ranges from 10.22% - 19.98%. The sections noted for their ability to produce grass fat cattle give the highest protein content test. This kind of grass is almost invariably produced on limestone soils.

Very little bluegrass in this section is every seeded. As soon as the land is cleared the grass will come in itself. It takes about 3-4 years to get a sod by this method of Nature. If properly managed this type of pasture will improve gradually for many years. Where the land is level a quick sod may be obtained by plowing and seeding a mixture of orchard grass, red top, red and alsike clover, tall oat grass, and timothy along with the bluegrass. Bluegrass and white



clover will eventually crowd out the rest. By this method more pasturage the first two years will be afforded and a quicker permanent sod obtained.

Temporary pastures, not involving the problem of care and maintenance over a period of years, are better understood. They require little management and merely occupy a short period in the crop rotation. The most common temporary pasture is the type that supplies forage for animals from early spring until late fall, such plants as rape, soybeans, cowpeas, vetch, field peas, rye and wheat. Perhaps the best way to manage such a pasture system is to have several fields fenced and rotate the animals from one field to the other as the crop becomes available for them. Abruzzi rye, sown in the fall will furnish some winter grazing and keep the animals in the spring until field peas, sown alone or with oats, are ready to pasture. Several seedings of these will keep forage until the field of rape, soybeans or cowpeas becomes available. In this way several fields of small acreage will maintain more animals than the same acreage in one field.

Temporary pastures require a complete knowledge of forage plants and winter cover crops; the date they must be sown in order to be ready for pasturage at a certain time, the amount of growth that can be expected, and the length of time animals of different kinds may be expected to maintain themselves on a certain area.

Temporary pastures are especially adapted to hogs, sheep and dairy animals.

## SEEDING PASTURES.

The seeding of pastures ranks in importance with the selection of the proper seed and the care of the matured pasture. Unless the seed is properly sown and under the correct condition, it will not grow successfully. The preparation of the ground and method of seeding are of utmost importance.

On the large ranges of the West, Nature must be relied upon to reseed the native grasses. Authur W. Sampson (34) after a close study of the growth of the native grasses and the life history of the vegetation found on the western ranges, makes the following observations:

"1. Removal of the herbage year after year during the early part of the growing season, weakens the plants, delays the resumption of growth, advances the time of maturity, and decreases the seed production and fertility of the soil.

2. Under the practice of year long or season long grazing, the growth of the plants and seed production are seriously interfered with. A range so used, when stocked to its full capacity, finally becomes denuded.

3. Grazing after seed maturity in no way interferes with flower-stalk production. As much fertile seed is produced as when the vegetation is protected from grazing during the whole year.

4. Deferred grazing (grazing after seed maturity) insures the planting of the seed crop and the permanent planting of the seeding plants without sacrificing the seasons forage or establishing a fire hazard.

5. Deferred grazing can be applied wherever the vegetation remains palatable after seed maturity and produces a seed crop, providing ample water facilities for stock exist or may be developed.

6. Year long protection against grazing of the range favors plant growth and seed production, but does not insure planting of the seed. Moreover, it is impractical because of the entire loss of the forage crop, and the fire danger resulting from the accumulation of inflammable material."

From the above facts that have been shown as a result of experiments and close observation, it seems that rotated or deferred grazing is the best way of reseeding native forage plants in the West, especially those within the National Forests where extensive experiments have been carried on.

In 1907 the Forest Service and the Bureau of Plant Industry started over 500 experiments to determine the value of reseeding depleted grazing lands to cultivated forage plants. (24) (25) (33). Every possible condition to be found on the 163 National Forests which cover 11 States, occupying the Western third of the United States, was experimented with to determine (1) when reseeding may profitably be undertaken, as shown, for example, by the soil and the character of the native vegetation; (2) what species to use; (3) when to sow; and (4) what soil treatment should be applied under the various conditions.

The seed was sown broadcast either by hand or machinery. No cultural treatment was given the soil before seeding. Close grazing had been the practice on these areas before seeding. The seed was covered by use of a brush or wooden peg harrow, or tramped by sheep.

Of the 449 experiments reported in 1911, 168 or 37.42% were failures; 112 or 24.95% were partial successes; 71 or 15.81% were fully successful; 64 or 14.25% were undeterminable, while 34 or 7.57% of the experiments were not fully determined.

Following is the grass or clover and the percentage of successful and partially successful results.

Timothy.....	64.37%
Smooth Brome grass.....	58.14
Perennial Rye grass.....	50.00
Italian Rye grass.....	37.50
Kentucky Blue grass.....	31.82
Redtop.....	33.33
White clover.....	41.67
Alsike Clover.....	14.82

Curves were plotted showing the percentage of successful and partially successful experiments in the following periods:

Spring - March; April; and May.  
Summer - June; July; and August  
Autumn - September; October; and November  
Winter - December; January; and February.

Autumn was shown to be best suited to seeding and Spring next. Or, by months October and May in the order named, were most satisfactory.

One or more of the following reasons named in the order of their importance was attributed to failure:

1. Lack of soil treatment
2. Drought.
3. Wrong selection of species.
4. Spring sowing.
5. Excessive competition with native vegetation.
6. Wrong time of sowing (other than spring).

Part failure was attributed to the following:

1. Spring sowing.
2. Lack of soil treatment.
3. Drought.
4. One or more species unadapted.
5. Excessive competition with native vegetation.
6. Wrong time of sowing (other than spring).
7. Overgrazing.
8. Excessive moisture for species sown.

Intensive studies were also carried on on plats varying in size from one-third to five acres. All possible conditions were taken into account on these areas. From these intensive studies the chief factors influencing failure in reseeding are:

1. Wrong time of sowing.
2. Inadequate planting of seed.
3. Use of species unadapted to conditions.
4. Excessive altitude

5. Soil which is either too shallow or of undesirable physical structure and chemical character, or which has too small or too great a supply of moisture.

Results showed that areas sown in Autumn were far superior to those sown in the Spring in the following respects.

1. Time of germination.
2. The period required for all of the seed to germinate.
3. The development and vigor of the seedling.
4. The subsequent loss due to adverse conditions, which determine the final end.

To determine the abundance of seedlings, actual counts were made. The redtop and bluegrass plats sown singly showed the most seedlings. Perhaps the reason that timothy did not show up well was that there was too dense a vegetation for the seed to reach the soil.

Brushing, tramping, and the untreated plats showed good results in the order named. Here timothy gave good results, perhaps because the weight of the seed carried it to the soil quicker.

In the particular area under consideration it was found that altitude seriously affected the growth of grass. The abundance or density of grass at 4800 and 7800 feet elevation bear the relation 7-3 respectively, while 7800 feet 100% less growth was produced than at 4800 feet elevation.

This seems to show that 7800 feet is the maximum elevation that grasses should be reseeded.

Intensive studies have established the following facts:

1. Under conditions seeding will be most successful if performed in the Fall after vegetative growth has ceased.
2. Inexpensive soil treatment, either in the form of brush or tooth harrowing, or by the tramping of sheep is highly important.
3. In endurance of drought smooth brome grass, timothy, Kentucky bluegrass, and redtop grade in the order named for high and low resisting power.

4. In the Wallowa Mountains an altitude of 7800 feet marks the highest limits at which reseeding is likely to pay. This is about 500 feet below timber line.

5. An acid soils may be recognized by the type of vegetation present.

When the species of forage is to be selected the following points are to receive especial attention:

1. Soil and climatic conditions in relation to the requirements of the various species.

2. Cost of the required amount of seed to establish a satisfactory stand.

3. The time required.

4. Ability of the species to withstand grazing.

5. The palatability, nutritiousness, and forage yield of the species.

On the logged-off lands of the West in most cases it is necessary to sow seed in order to make a pasture. Commercial seeds have to be bought and used. These are usually sown in mixtures. The cultural method of such seeding has been considered elsewhere.

The following are mixtures suggested for different types of land, the number of pounds of seed used per acre for each kind of grass in each mixture: (31)

For wet land:	Italian rye-grass 8
	Redtop 4
	Timothy 3
	Alsike clover 3
	White clover 1

For moist land:	Italian rye-grass 6
	Orchard grass 4
	Kentucky bluegrass 4
	Timothy 2
	Redclover 4
	White clover 1

Upland (permanent): Italian rye-grass 8  
 Orchard grass 5  
 Kentucky bluegrass 4  
 Red clover 4  
 White clover 1

Upland (temporary): Italian rye-grass 88  
 Timothy 3  
 Orchard grass 5  
 Red clover 5  
 White clover 1

The seeding of Eastern pastures presents a different problem for each locality. Good pasturage should be:

1. Nutritious and palatable.
2. Long lived.
3. Able to reproduce itself without production of seed.

The most common grasses meeting these requirements are Kentucky bluegrass, timothy, redtop, orchard grass, meadow fescue and white clover.

For reseeding old pastures or sowing down new ones, the following mixtures are recommended(42) showing the number of pounds of seed used per acre.

Average loamy soils:	Timothy.....	8	pounds
	Kentucky bluegrass..	6	"
	Redtop.....	3	"
	Orchard grass.....	3	"
	White clover.....	4	"
For heavy soils inclined to be wet:	Timothy.....	6	"
	Kentucky bluegrass..	6	"
	Redtop.....	4	"
	Meadow fescue.....	4	"
	White clover.....	4	"
For soils inclined to be be light and dry:	Timothy.....	10	"
	Kentucky Bluegrass..	10	"
	Redtop.....	4	"
	White clover.....	4	"

Pastures may be plowed and seeded either in the Spring or in the early Fall(August). When sown in the Spring, 2 bushels of oats or barley per acre should be sown as a nurse crop to protect the young grass.

In New York pasture mixtures have been studied to the extent

that it is known on just what type of soil certain plants will grow and what mixture is best suited to each type of soil. (7) Three distinct pasture types are found; (1) the bluegrass and white clover type is found on productive soils having sufficient lime to grow red clover. This pasture is the ideal one and is the ultimate aim of every pasture manager. (2) This class is known as the redtop and bluegrass type. This pasture occupies the hill land of the state. Red clover is especially fitted to poor damp soil, lacking lime. (3) The fine bent grass pasture is found on virgin soils, where the land has been cleared but never cultivated. This grass seems to do best on wet, acid soils where 3-4 tons of lime are necessary on the land before clover will grow.

At the Delaware Station (15) the chief pasture grasses have been found to be timothy, orchard grass, redtop, Kentucky bluegrass, Canada bluegrass, tall meadow oat grass, the fescues and rye grasses. The main clovers are red, mammoth, alsike, white and Japan.

In seeding pasture mixtures it is desirable to include those seeds which will give an early growth in the Spring, and grow throughout the summer and early Fall. The periods of maximum growth should be spaced throughout the entire season.

The following are some mixtures recommended at the Delaware Experiment Station:

On rich clay loam	Timothy.....	8	pounds
drained land:	Kentucky bluegrass....	4	"
	Canada bluegrass.....	2	"
	Meadow fescue.....	2	"
	Orchard grass.....	2	"
	Red clover.....	6	"
	Alsike Clover.....	3	"
	White clover.....	2	"
On light sandy loam:	Redtop.....	10	"
	Kentucky bluegrass...	6	"
	Canada bluegrass.....	2	"
	Brome grass.....	14	"
	White clover.....	2	"
	Japan clover.....	4	"



On Low wet land:.

Redtop.....	10	Pounds
Perennial rye grass..	6	"
Meadow fescue.....	6	"
Alsike clover.....	8	"
White clover.....	4	"

On very poor acid land:

Timothy.....	5	"
Redtop.....	5	"
Alsike clover.....	5	"
White clover.....	5	"
Japan clover.....	6	"

For a temporary pasture used in a rotation, those grasses that take several years to develop should be omitted.

For a temporary pasture on lands of reasonable fertility and well drained, the following mixture in pounds per acre should be used:

Timothy.....	12	pounds
Red clover.....	8	"
Alsike clover.....	4	"

On wet or low or acid lands:

Timothy.....	4	pounds
Redtop.....	8	"
Alsike clover.....	8	"
Red clover.....	4	"

On well limed and fertile soils in Virginia the best method of seeding pastures is in the fall with small grain. The clovers can be seeded in the early spring. Care should be taken to cover the seed by harrowing lightly, or by sowing with a drill. On the poorer soils of the State, the nurse crop should be omitted.

Pasture mixture, showing the number of pounds per acre, recommended (1) (2) on strong loam and clay soils:

Kentucky bluegrass.....	14	pounds
Orchard grass.....	14	"
Meadow fescue.....	5	"
Red Clover.....	4	"
Alsike clover.....	3	"
Redtop.....	2	"
Alfalfa.....	6	"
White Dutch clover.....	2	"

On light loams and sandy soils:

Tall oat grass.....14 pounds	Tall oat grass.....8 pounds
Orchard grass.....14 "	Orchard grass.....14 "
Redtop..... 5 "	Perennial rye grass... 6 "
Alsike clover..... 5 "	Redtop..... 2 "
	Alsike clover..... 4 "
	Red clover..... 3 "
	Alfalfa.....
	Sweet clover..... 4 "

Bluegrass pastures require special treatment in seeding. In Missouri (5) it is recommended that timothy and bluegrass be sown with wheat in the fall and clover added in the spring. After the wheat is harvested the hay and clover crop will last for two years and in that time the bluegrass should have a good start and will fill the sod as the timothy disappears. The rate of seeding should be:

Timothy.....8-10 pounds per acre.
Bluegrass.....6 " " "
Clover.....6-8 " " "

On untillable land sow the above mixture in the spring. On less productive soils add some orchard grass and alsike and red clover. In nearly every case, seeding in March will be found to give better results than in the Fall.

The Montana Station (8) reports the following mixture best suited to sow on the irrigated pastures of that State:

Kentucky bluegrass.....4 -6 Pounds
Smooth brome grass.....3 -4 "
Orchard grass.....4 -6 "
Meadow fescue.....3 -4 "
White clover.....1 -2 "
Alsike clover.....1 -2 "

Spring seeding in stubble has given about the same results as Fall seeding with or without a nurse crop.

The Idaho Experiment Station (10) does not recommend Fall seeding of pasture mixtures on irrigated land. The grass sown even as early as September 17, did not attain sufficient growth to prevent winter killing. Late Spring or early Summer seeding has been found best

Broadcasting is just as satisfactory as drilling and much cheaper, hence, it is recommended as the most satisfactory method of seeding. A brush or spike tooth harrow can be used to advantage to cover the seed.

Almost every section of the country demands different seeds, and each section should be individually considered when recommending a seed mixture. Conditions existing are of utmost importance. There is one policy that never changes and can be relied upon always, as the best. That is, use the best seed that can be obtained. (32).

Cheap, inferior seed is poor at any price. When the old pastures are reseeded, or new pastures seeded, no chance should be taken that can be avoided. The money expended is more or less an investment and if through the use of poor seed, it fails, there is a total loss of all money expended. Poor seed is the direct reason for many pasture failures.

There is very little excuse for the farmer to buy inferior seed through ignorance. State laws require seed merchants to label their products as to germination and purity, and by means of inspection and analyses, enforce it.

Whether the ranges should produce fat cattle or cattle for the feed lot, is a matter that will influence the character of a pasture. On the whole the best that can be done is to consider carefully what is best for the range and not be governed by rules.

Over a period of years, it has been found that 2 1/2 acres of land growing good forage, will maintain one sheep and ten lambs over a 12 day period. On the National Forest Ranges in Montana it was found that 7.37 acres would keep a cow for 100 days, or in other

## CARRYING CAPACITY OF PASTURES.

The National Forest Ranges in the West have been studied extensively to determine their carrying capacity. Various factors entered into this determination where conditions were observed over a period of years. (24)

On a given tract of land, there may be large areas that are of no grazing value due to some of the following reasons: (1) The vegetation may not be palatable to stock; (2) grazing may be impracticable due to ruggedness, fallen timber or brush; and (3) the range may be good, but too inaccessible to be of any value. On one range under observation 50% of the total area was rendered useless by reason of the above mentioned factors.

The amount of forage per acre is another important factor to be considered in estimating carrying capacity. 100% variation often exists in a single unit. There is also a considerable difference in the amount and quality of forage produced in different years. The palatability of the forage plant under consideration has a good deal to do with the carrying capacity of pastures. It is not a sign of understocking when quantities of forage low in palatability are left on the range at the end of the grazing season.

Whether the ranges should produce fat cattle or cattle for the feed lot, is a matter that will influence the capacity of a pasture. On the whole the best that can be done is to consider carefully what is best for the range and not be governed by rules.

Over a period of years, it has been found that  $2\frac{1}{2}$  acres of land growing good forage, will maintain one sheep and two lambs over a 72 day period. On the National Forest Ranges in Montana it was found that 7.37 acres would keep a cow for 100 days, or in other

words, a cow required 27 acres to maintain herself one year. In southern Idaho 10 acres maintained a cow for  $5\frac{1}{2}$  months. Foothill pasture in southern Arizona furnished 365 cow days feed over a period of years on 14 acres. In New Mexico 20-30 acres were necessary for each cow, and during the summer months a larger area was needed.

Good management should reduce the acreage requirement as much as 10-15%.

In 1915 Shepperd at the North Dakota Station (35) began an experiment to determine the carrying capacity of native pastures without regard to their maintenance or improvement. 2 year old grade-bred range steers were used as the standard grazer.

250 acres were used in the experiment. In 1915 the entire area was grazed on the basis of 5 acres per steer. In 1916 the pasture was divided into 30, 50, and 100 acre fields. Ten steers were placed in each field, making the ratio 3 - 5 - 7 - and 10 acres of grass per steer.

Questionnaires sent to over 200 North Dakota farmers and breeders gave the reply that 6 - 12 acres were necessary to maintain a 2 year old steer one season.

The same live weights were pastured on the same field from year to year. After two years of grazing the 3 acre-to-the-steer pasture was exhausted. The third year this pasture lasted 106 days. The 5 acre-to-the-steer pasture lasted 137 days of its third year. The 7 acre-to-the-steer pasture carried the cattle satisfactorily, and as a result of four years study is considered the minimum acreage a 2 year old steer can do well on when pastured on these North Dakota ranges

During a feeding experiment in North Carolina it was found that two year old cattle used three acres of pasture per head during the summer months, while to winter these animals only two acres was necessary.

On the cut-over lands of the Piny Woods section of the South, for spring and early summer grazing, five acres for each steer was sufficient. The result of a number of questionnaires sent to the farmers and breeders of this locality brought the reply that steers required from 4-20 acres, with an average of 8.3 acres. It is a safe recommendation to say that 10 acres will maintain a steer for a period of 8-9 months.

In the Pacific Northwest one acre of good pasture land will keep a fattening sheep for 630 days or ten sheep for 63 days.

The question of what is a good pasture has been asked many times of farmers and others interested in this problem. The answers have been varied. The general opinion being that any pasture that will furnish abundant grass from  $2\frac{1}{2}$  acres for a 1,000 pound cow or steer during the grazing period, may be called a good pasture. (12)

The West Virginia Experiment Station in 1915 began a survey of some of the poorer counties of the State to determine among other things the amount of land required to maintain livestock. "A survey of six counties in the State showed that it required approximately 4 acres of pasture to graze a cow and a little more for a three year old steer." (12)

This seems to show that the general conception of carrying capacity of pastures in that State is wrong, and that the farmers who have been taking this figure as correct are unknowingly overgrazing their pastures, the final result of which is certain pasture deterioration.

THE LEADING PASTURE GRASSES.

The most important tame grazing grasses found on American pastures are Kentucky bluegrass, redtop, white clover and Bermuda grass. Those of less importance are timothy, orchard grass, Canada bluegrass, red clover, alfalfa, alsike and Japan clover and crab-grass.

Kentucky bluegrass is by far the most valuable pasture plant in the North, just as Bermuda grass is valuable in the South. White clover and redtop will grow in all sections except the semi-arid and extreme southern regions.

Piper, of the United States Department of Agriculture, gives the tame permanent pasture grasses the following scores on a basis of 100 as to their relative importance in America. (47)

Kentucky bluegrass.....	40
Redtop.....	10
White clover.....	8
Bermuda grass.....	8
Timothy.....	8
Red clover.....	4
Alfalfa.....	4
Alsike clover.....	3
Canada bluegrass.....	3
Orchard grass.....	2
Johnson grass.....	2
Lespedeza.....	2
Crab-grass.....	2
All others.....	4

The author of these grades makes note of the fact that they are merely rough estimates. A brief discription of the above grasses will be given, taken in order of their relative importance. (27) (29) (30) (37) (39) (40) (43) (45) (46) (47) (49)

Kentucky bluegrass (*Poa pratensis*) is also known as June grass, or simply bluegrass. It is seldom used for hay, making a too short growth and low yield, but is admirably suited for pastures. It makes its best growth on well drained clay or clay loam soils rich in humus. The period of its greatest growth is in the fall and spring. This

grass is very resistant to cold but cannot withstand the hot dry seasons of any length. It is not grown very successfully south of Virginia and Kentucky.

Redtop (*Agrostis alba*) is commonly called herds grass in the South. The English call it bent grass. It will grow under almost any condition of soil and climate found in the United States except the semi-arid regions of the West, and the extreme South. It thrives best on wet or moist clay soils, is very resistant to cold, and can stand summer heat very well even on poor upland. It is rarely found growing in a shaded position.

White clover (*Trifolium repens*) is also known as Dutch clover and white trefoil. It thrives best on a cool moist climate, growing from the northern limits of agriculture almost to the Gulf of Mexico. It is an important winter pasture in the South. Loams and clay loams favor its growth, especially when rich in humus and fairly well drained. White clover will grow well in shade, which makes it very desirable as an orchard soil. It is an important lawn mixture also. (21) Due to its property of nitrogen gathering it is very desirable to have in a bluegrass pasture sod, even though the bluegrass will kill out the clover in time.

Bermuda Grass (*Cynodon dactylon*) a long lived perennial, is a native of India. In Virginia where its growth is only sufficient to cause trouble, it is known as wire grass. The grass occurs from Pennsylvania west to central Kansas, and south to the Gulf of Mexico. It is also found in Arizona, New Mexico and California. It is not adapted to cold, though some plants seem to be becoming acclimated. It will not grow in the shade. This grass is the foundation of the best permanent pastures found in the South. On account of its ability to grow on any soil type and because of its creeping character, Bermuda grass is often used on badly eroded poor soil to prevent further wash-



ing of gullies. It acts as a soil builder in such cases. Bermuda grass is more often propagated by cuttings than by seeding.

Timothy ( *Phleum Pratense*) is distinctly a Northern grass. It does not well stand hot, humid summers and does not grow successfully in the cotton belt. Timothy is best adapted to moist clay and loam soils.

Some advantages of timothy:

1. It produces a good yield.
2. A stand is usually secured easily.
3. The seed is usually high in purity, germinates well and the cost per acre is less than that of any other grass.
4. It seldom lodges.
5. It is easily cut and cured.
6. The period during which it may be harvested is longer than that of most grasses.
7. It is the favorite hay for city horses and the demand is therefore greater than that of other hays.

Some objections to timothy:

1. Its lateness.
2. Becomes somewhat woody
3. Comparatively low in nutritive value.
4. Small amount of aftermath.

Red clover (*Trifolium pratense perenne*) has a very high nutritive value. It is most important leguminous crop grown in America. Almost any well drained soil, not subject to drought, will produce red clover. It is best adapted to a humid climate not having extreme winter or summer conditions. In the South it is regarded as a short lived annual because it cannot withstand hot summers. In the Pacific Northwest three year yields are not uncommon. In pastures it will last a long time, probably longer than if not grazed.

Alfalfa (*Medicago sativa*) is the oldest known forage plant and where it will succeed is undoubtedly the best legume for permanent meadows. Alfalfa may be pastured to all kinds of livestock, but this is rarely done in regions where the hay commands a good price. In pasture mixtures, alfalfa is very likely to become crowded out by such grasses as Kentucky bluegrass. Alfalfa has proven fairly well adapted to nearly all soils that are deep, reasonably fertile, well drained and rich in lime. Grimm's alfalfa is the best seed to use if there is any danger of winter killing, as this variety is very hardy.

Alsike clover (*Trifolium hybridum*) thrives in a cool moist climate, very seldom winter killing. It is almost as widely adapted to climatic conditions as white clover. It will grow well on almost any soil, even where the soil is water-logged, thereby showing its adaptability to irrigation. On low, wet pastures alsike is often used. It is a very palatable pasturage, and because of its adaptability, has in many places replaced red clover.

Canada bluegrass (*Poa compressa*) also known as Virginia bluegrass, is seldom sown pure except on poor rocky clay soils where it will give a good pasturage as any single grass and is recommended. This grass will grow wherever Kentucky bluegrass will, and is more resistant to summer heat and drought. Unlike Kentucky bluegrass, this grass is usually found on poor thin soils. Probably this is not from preference so much as its inability to cope with the other grasses. Its main usefulness is where Kentucky bluegrass will not grow.

Orchard grass (*Dactylis glomerata*) should be a part of pasture mixtures wherever it will grow. It grows during cold weather and will

furnish pasturage early and late. In the United States its growth is more abundant in the South than in the North. As it begins growth very early in the spring, an early frost is very likely to kill it. Orchard grass is a little more hardy than timothy and will grow in all types of soils except sand and muck. It prefers a clay or clay loam with a moderate amount of moisture. It grows exceedingly well in the shade. This grass is a very good soil builder and is used as such on many areas subject to erosion.

Johnson grass (*Andropogon halipensis*) was considered a weed until about 1885 when it was distributed by the California Experiment Station as a new forage plant. It grows on all types of soil found in the cotton belt, but seems to prefer rich land and an abundant supply of moisture. From Virginia and North there is no reason why the grass should not be grown as a cultivated grass as it is winter killed every season. Johnson grass does not bear grazing well as the root stocks are weakened and growth is hindered.

Lespediza (*Lespedeza striata*) or Japan clover is remarkable for its ability to grow on any soil, even the poorest sand. It is the most valuable self seeding legume in the cotton belt. It does best on rich calcareous loams or clay loams. It requires a well drained soil, but occurs abundantly in moderately open woodland. This clover will withstand heavy grazing but if moderately grazed will last for an indefinite period. When it is grown for pasturage, Bermuda grass or redtop should be included in the mixture.

Crab-grass (*Digitaria sanguirealis*) is an annual weedy grass which appears with hot weather and is promptly killed by the first frost. It makes an abundant growth in cultivated ground and in the South is cut for hay. It is a spontaneous crop, never being sown or handled commercially. It is a destructive weed in lawns.

## USE AND PURPOSE OF MEADOWS AS DISTINGUISHED FROM PASTURES.

A meadow in the generally accepted meaning of the word, is a field growing permanent grasses which are cut and harvested, either being sold by the grower or used to feed livestock on the farm where grown. The purpose of a meadow is to furnish high grade hay crops year after year with the least amount of labor and attention consistent with the maximum yields.

A pasture, likewise, is a permanent grass field, but is used to maintain livestock during the entire growing season, thus doing away with cutting and harvesting, and the necessary labor attached thereto. The purpose of a pasture is to furnish palatable grazing for as long a period as possible during the growing season, which is consistent with the maximum growth and value of the pasturage.

While meadows and pastures may be temporary, laying from 1-3 years, the general interpretation of the words is that they are permanent sods.

MEADOW MIXTURES

For hay meadows in the United States, it is not the practice to sow complicated seed mixtures. In Europe (45) it is the custom to sow bottom and top grasses. The bottom grasses are short and tend to form the sod, while the top grasses are tall and do not have a tendency to form a close sod. The bottom grasses are supposed to increase yields and to provide better pasture and a longer lived meadow. The system of sowing a bottom and a top grass mixture has never gained any prominence in America.

There are 45,000,000 acres of tame grass meadows in the United States seeded as follows:

Timothy and clover (half together and half separately).....	37,000,000 acres.
Alfalfa.....	4,000,000 "
Other tame grasses.....	4,000,000 "
Total tame grasses.....	<u>45,000,000 acres</u>

Of the "other tame grasses", it is not known how much are mixtures or how much is seeded alone. These figures show, however, that the great majority of meadows in the United States are not sown with complicated mixtures.

The principal objects desired in a meadow mixture are to secure plants of varying habits, adapted to the different conditions under which they grow, and to have them mature at the same time.

Over 80% of the meadows of the United States contain timothy either in combination or alone. Piper(47) states the following as the result of much experimentation and close observation of meadow mixtures:

"1. Timothy and red clover, the standard mixture for the timothy region, on well-drained soils. Where red clover fails, it may be replaced with alsike, or both clovers may be used. Frequently redtop is added to the mixture.

2. Redtop and alsike clover for low wet lands in the timothy region. If the land is not too wet, timothy may be added. Fowl meadow-grass is also well adapted to such soils.

3. Orchard grass, tall oat-grass, and alsike clover. This mixture is especially desirable where timothy and red clover do not succeed well. Italian rye-grass may be added to this mixture to increase the yield of the first crop.

4. For semi-humid regions brome and timothy or brome and orchard grass.

5. Where alfalfa thrives, it makes good mixtures with timothy, tall oats, slender wheat or brome-grass.

6. Disadvantage of the red clover-timothy mixture is that clover matures ten days earlier than timothy. Orchard grass also ripens too early and redtop too late for timothy. As alfalfa is usually cut three times and clover once a season, it is undesirable in a mixture. Mammoth clover is preferred by some as it matures the same time with timothy.

While timothy is supposed to have a longer period during which it may be harvested than most grasses, experiments at the Missouri (47) Station have shown that the time of cutting influenced yield, digestibility, and palatability of the hay to a rather surprising degree.

The red clover-timothy mixture is recommended for the following reasons: (45)

1. Greater yield of forage. Timothy does not usually come to full yield the first year, while clover usually dies at the end of the first year. It benefits the soil and gives the timothy a better growth the second year.

2. The roots of red clover penetrate deeper than timothy roots, so the two can grow together without direct competition.

3. The feeding value of the hay is much greater, as clover is rich in protein. On the city market, timothy alone is more desirable.

The uniformity of soil conditions is in many cases the reason for meadow mixtures, as a grass that flourishes on one soil type might not grow on another type in the same field.

Four common mixtures showing the number of pounds used per acre: (45)

For good timothy and red clover soil:

Timothy.....15 pounds  
Red clover.....10 "

Where red clover fails in spots:

Timothy.....15 pounds  
Red clover..... 5 "  
Alsike clover..... 3 "

Where both timothy and red clover fail in spots:

Timothy.....15 pounds  
Redtop..... 5 "  
Red clover..... 5 "  
Alsike clover..... 3 "

Where timothy and red clover fail:

Redtop.....10 pounds  
Alsike clover..... 5 "

The following are seed mixtures recommended for hay in Virginia (1).

On strong clay soils:

10 pounds of timothy                      9 pounds of timothy  
8 "                      " sapling clover                      8 "                      " clover  
5 "                      " redtop                      5 "                      " alfalfa

On light loam and sandy soils:

Tall oat grass.....11 pounds  
Orchard grass.....11 "  
Medium red clover..... 3 "

On wet bottom lands:

Timothy..... 8 pounds  
Redtop..... 3 "  
Alsike clover..... 5 "

## CULTURAL METHODS

Yields on permanent meadows can usually be increased by:

1. Plowing and harrowing.
2. Occasional reseeding.
3. Use of fertilizers.

Any one of these methods or a combination of them may be used in treating a meadow. In the case of a Johnson-grass-Bermuda-grass meadow, plowing and harrowing will greatly increase the yield of the grass. Plowing tends to stir up the root-stocks and stimulates growth.

Harrowing alone, on some types of meadows may increase yields. The spring is usually the time of the year that this cultural method is applied. This scarifying, done with a disk or harrow, usually increases growth of the grasses. Care and judgement must be exercised or the increased growth will consist largely of weeds. The practice of plowing and harrowing in conjunction with reseeding or the application of fertilizers will be taken up under the last two methods.

Occasional reseeding is perhaps the best treatment for maintaining meadows. On some land hay has been the only crop grown for years. Where such a long continuous crop is grown, there is a change of undesirable plants gaining supremacy over the desirable one, and weeds are very likely to gain a foot-hold. Mosses and lichens are also liable to appear when the sod remains undisturbed for a long number of years. These latter are supposed to denote a lack of lime, but even lime does not always eradicate them. Even when fertilizers are added annually, a meadow will, in time, deteriorate.

At the Massachusetts Experiment Station (50) it was found that plowing and reseeding increased yields approximately 25% over the undisturbed meadows, both areas receiving the same fertilizer treatment. Wood ashes were used in this experiment. On plats treated with 8 tons of barn-year manure, the increase due to plowing and reseeding, was almost 50%.



On areas difficult to plow it is the practice in some localities to scatter seed over the meadow each year. By applying the most desirable seeds the meadow is maintained in a very good state of improvement. When it is possible to harrow in the seed even better results are obtained.

In seeding meadows it is desirable to secure a strong uniform stand of the desired grasses and clovers in the right proportion and without weeds or thin spots. On good soils well adapted to growing hay, a stand of hay may be easily secured by sowing timothy with wheat in the Fall and adding clover the following Spring. Where conditions are unfavorable and this practice is unwise, more care must be given.

When poor soils or dry conditions exist, grass and clover should be sown alone. The grass should be seeded in August, allowing sufficient time for a good growth before frost to insure against winter killing and the clover sown the following Spring.

It is usually advisable to sow nurse crops with grass. In general, sow the nurse crop thick so that it will not prevent a good uniform growth of grass. On poor land, or in a dry season, the grass will have a better opportunity if the nurse crop is decreased.

The use of fertilizers as a method of increasing yields on permanent meadows will be treated under a separate head.

## FERTILIZERS FOR MEADOWS.

A large percentage of all the hay grown in the Northeast portion of the United States and the adjacent land of Canada, is timothy and red clover, with a small sprinkling of redbtop and alsike clover. The common crop rotation in this section is corn - oats - wheat - clover and grass for two years, or corn - wheat - clover - and grass for two years. About  $\frac{3}{4}$  of the hay produced in this section is grown on land in such rotation. Perhaps  $\frac{1}{4}$  of the hay is produced on permanent meadows. In the above mentioned rotations, it is very rare that any fertilizer is applied to the hay crop. Hay, therefore, receives only the residue of the fertilizer applied to the grain crops. With this principal of fertilization, the average yield of hay in the region mentioned is about 1.3 tons per acre. A 2 ton yield is considered exceptionally large. Yields of 5-6 tons per acre have been secured where very large applications of fertilizers have been made. There is usually an abundance of rainfall in this region, so that the principal limiting factor of production is the fertility of the land.

Results of experiments conducted over a number of years at the Ohio Experiment Station (41) show the residue of fertilizers from grain crops, as a rule, give a good increase over unfertilized areas.

Experiments have been carried on to determine whether or not it is better to apply fertilizer to the hay crop or grain crop in a system of rotation. It is still an open question as to which method is the better.

Lyon and Morgan (41) in discussing the subject, advance the following reasons why it is better to apply fertilizer to the hay crop in New York:

"1. Fertilizer applied to grass increases not only the growth of that part of the crop cut for hay, but also the roots and sod which are plowed under the soil, and in decomposing add to soil productiveness. It seems

therefore, that anything that aids the growth of timothy would help the grain while the reverse is not true in the same sense.

2. The hay crop is usually the crop which in rotation with the grain brings the largest financial returns in New York State. If a certain application of manure increases in the same ratio the yields of hay and grain, the value of the increase in the former crop would be greater than that of the latter. It would pay best to increase the crop that is worth the most, provided the cost of the increase is the same in both cases.

3. Grass is peculiarly sensitive to readily available nitrogen in fertilizers. Grain crops are not benefited to the same extent by this form of nutritive. As most commercial fertilizers contain some more or less readily available nitrogen, much of which may be carried off in the drainage water, and then be lost to crops after the year it is applied, it would seem to be advisable to apply this to the crop that it will benefit most. On the other hand the phosphorous and potassium contained in the fertilizer are not removed in large amounts by the drainage water and the unused parts remain in the soil to benefit the succeeding grain crops."

Whether or not it is best to fertilize hay in a rotation, there are times when the application of fertilizer to the hay crop is very profitable, especially when the fertilizer is cheap and there is a good city market near at hand.

The application of well-rotted manure on meadow lands has given better results than the best fertilizer mixture at the New York Experiment Station (36). Where the cost of the manure applied has been less than \$1.50 per ton, it has proved more profitable than fertilizer.

Experiments have shown that the residual effect of manure applied to a meadow is of as much value to succeeding grain crops as if it had been applied direct to them. Fertilizers applied in the same manner have the same residual value for the following crop. The reason for the effect

of this residual fertilizer is not entirely understood. One explanation is that the increase in growth of the timothy caused by the treatment leaves a greater store of organic matter in the soil.

Manure is to be used as a top dressing should be well rotted. By using most of the manure available as a top dressing for a meadow in rotation, better results would be obtained, than by applying the remainder to the sod to be turned under for corn. A light dressing of 6-8 tons per acre would show marked increases in hay as well as corn.

The Massachusetts Experiment Station (50) reports that a top dressing of muriate of potash to a mixed plot of timothy, redtop, and clover caused a remarkable increase in the yield of clover. Sulphate of potash was found to increase the yield even greater, the difference in the two potash salts being very noticeable on the yields.

From these experiments, Brooks suggests that hay crops in rotation be top dressed about the first of May with the following fertilizer mixture per acre:

Nitrate of soda.....	175-200	pounds
Acid phosphate.....	50-100	"
High grade sulphate of potash...	50-100	"

When a greater percentage of clover is desired, the following mixture is recommended:

Acid phosphate.....	100	pounds
Basic slag.....	400.	"
High grade sulphate of potash.....	150-200	pounds.

When large yields of hay are desired heavy annual applications of a complete fertilizer is necessary. (47) Wheeler, at the Rhode Island Experiment Station, secured yields of hay for three years averaging over 4 tons per acre. The following fertilizer was used:

Nitrate of soda.....	350	pounds
Acid phosphate.....	500.	"
Muriate of potash.....	200.	"

Such applications are not practicable in the long run, as a dry season would cause much of the fertilizer to remain unavailable and consequently be lost.

At the Wisconsin Experiment Station (47) on peat muck soils a mixture of timothy and alsike yielded 2727 pounds of hay per acre. 275 pounds of acid phosphate increased the yield to 5015 pounds per acre. 100 pounds of sulphate of ammonia increased the yield to 4588 pounds per acre. These two fertilizers used together failed to increase the yield of hay more than either alone.

The application of barnyard manure and commercial fertilizer greatly increased the yields of timothy at the West Virginia Experiment Station. (47) The four acre field treated yielded 1 ton or less per acre before any manure was applied. The application of 17 tons of manure in one year brought the yield up to 3775 pounds per acre. At the end of six years similar treatment the yield was 11,315 pounds per acre with an average of 8,044 pounds per acre for six years. A fertilizer containing nitrate of soda, acid phosphate, and sulphate of potash gave an average yield of 3775 pounds per acre of hay, the average annual cost of the fertilizer being \$11.76. In both cases large profits were realized.

Recent experiments (15) at the Delaware Station lead to the following conclusions:

"1. For mixed clover and grass meadows apply a top dressing of 100 to 150 pounds sodium nitrate and about 50 pounds of muriate of potash per acre, or 125-300 pounds of acid phosphate and about 50 pounds of muriate of potash per acre."

"2. For meadows in a rotation where clover predominates an application of 250-400 pounds of acid phosphate and 50-100 pounds of muriate of potash is recommended. Where timothy and mixed grasses predominate

the following is recommended:

Nitrate of soda.....	150-200	pounds	per	acre
or				
Ammonium sulphate.....	150-150	"	"	"
and				
Acid phosphate.....	50-150	"	"	"
Muriate of potash.....	25-75	"	"	"

"3. An application of lime not only increases the yield of hay but improves the quality. It is essential for the growth of clover. Where lime and fertilizers are applied, the meadows are freer from weeds."

"4. Every pasture or meadow is a problem by itself and will have to be treated according to the individual needs."

"5. Light grazing is as dangerous as overgrazing."

The above conclusions were reached after 9 years work with pastures and meadows.

At the Pennsylvania Station (14) it is recommended that fertilizer should be applied as a top dressing just as the grass is beginning to grow in the Spring.

The amount and proportion of the different ingredients vary with the different conditions found. For average conditions 25 pounds of nitrogen, phosphoric acid, and potash per acre is recommended. 150 pounds of nitrate of soda, 150 pounds of acid phosphate, and 50 pounds of muriate of potash will furnish these elements in the right proportion.

The best method of getting a good stand of grass in Virginia (2), is to sow the seed alone in the late Summer with the direct application of the fertilizer. On most soils an application of acid phosphate and some form of nitrogen will be sufficient to grow grass. On light sandy soils potash may be added. When clover is grown, and it should be grown, small amounts of nitrogen should be added to the fertilizer. 100 pounds of nitrate of soda applied broadcast just as the grass is beginning growth in the Spring stimulates growth. 200-400 pounds of acid phosphate is recommended. Where potash is lacking 50-100 pounds of muriate of potash

is recommended.

An additional application of 50-100 pounds of nitrate of soda and 200-300 pounds of acid phosphate in the Spring before the second year crop is to be harvested is profitable.

Lime is necessary for clover growth. 1 ton of burnt limestone or 2 tons of ground limestone is usually sufficient to correct soil acidity enough to grow good clover.

All Virginia soils require acid phosphate before they can produce maximum crops of hay. On the thin soils of the State, potash and nitrogen must be supplied. Especially is nitrogen necessary to the poor soils of Virginia before hay will grow successfully,

## CONCLUSIONS AS TO THE MANAGEMENT OF PASTURES AND MEADOWS.

As a result of a review of the available literature on pastures and meadows, a number of important facts become evident.

On a basis of total acreage of the country, pastures especially occupy large areas. When it is considered the number of head of livestock, especially cattle that this acreage makes possible to be marketed each year, a slight idea of the importance of pastures may be gained.

The pastures of the country are of two types, permanent and temporary. Each meets a certain definite requirement, but the former occupies a larger place in American agriculture and needs more study at the present time.

The cultural methods that can be applied to pastures are as varied as the number of conditions that can be found. On the ranges of the West the principle of deferred grazing has been found to be as satisfactory as any method of pasture improvement. On certain areas, reseeding artificially has been found practical.

On the pasture lands of the East a different system of management must be followed. No matter what system of management is in use, overgrazing and premature grazing will cause it to be unsuccessful.

Eastern pastures very often contain bluegrass as their main growth. While clover is usually found also, especially if there has been recent application of lime. There are very few pastures that one ton of lime would not improve, if only to stimulate white clover growth which in turn would supply nitrogen to the soil. 200 pounds of acid phosphate whenever a pasture shows signs of deterioration, in conjunction with lime is almost universally recommended to keep up pastures.

Plowing and reseeding is often the best way to handle a worn out pasture.



There may be as much harm in undergrazing as overgrazing a blue-grass pasture.

Pastures should be seeded with plants best suited to the existing conditions.

Natural reseeding is most desirable. Often seeding may be accomplished without plowing. In such cases, if possible, the seed should be harrowed in. Otherwise sow at a time alternate thawing and freezing will work the seed into the soil. When plowing, prepare the seed bed carefully and fertilize. Avoid too early grazing on a newly formed sod.

Individual attention should be given each problem of pasture carrying capacity. The animal, length of grazing, object of grazing to maintain or fatten - the condition of the pasture, and season, will all have to be considered when the number of head per acre is being estimated.

Complicated meadow mixtures are not as common in America as they are in Europe. Timothy and some clover adapted to soil and climatic condition is the mixture found in the region where timothy will grow. Red clover is suited on well drained lands. If the soil is inclined to be wet, alsike clover or redtop should be used. When the climate is too hot for timothy, Bermuda grass may be substituted. Alfalfa and red clover are often used with Bermuda grass in the cotton belt.

In selecting a meadow mixture, care should be used, making sure that all the plants in the mixture will mature at the same time as the main crop, timothy in the North and Bermuda grass in the South, as all must be cut at the same time.

The application of farm manure to meadows is more profitable in rotation than application to the grain crop.

Acid phosphate and lime, potash when lacking, in the form of a sulphate, and nitrogen in a readily available form in small amounts

to stimulate growth, usually meet all of the requirements of fertilizers on meadows. 200-400 pounds of acid phosphate, 75-150 pounds of a muriate or sulphate of potash when needed, and 50-100 pounds of a nitrate of soda applied as a top dressing just as the grass starts to grow in the Spring, is a good fertilizer treatment for the average meadow.

Meadows should be well fertilized from time to time, whether in rotation or a permanent lay. Meadow soils need as much replenishment of plant food elements as do cultivated plants, because grass uses the plant food in the soil as well as do cultivated crops.

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