FACTORS AFFECTING PASTURE QUALITY

An Inventory of Soils, Vegetation, and Management of Maryland Permanent Pastures.

By

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INTRODUCTION

Permanent pastures on Maryland farms are definitely an integral part of the agricultural system, more particularly so in the dairying and the stock-raising sections. It is a recognized fact that the quality or degree of excellence of most pastures is considerably lower than that which agronomists would characterize as satisfactory. The factors which influence pasture quality have been the subject of numerous investigations, but the extent to which these factors occur in Maryland pastures has been imperfectly known. It is felt that, with a more complete knowledge of pasture conditions in the state, the task of improving pasture quality could be accomplished with conviction and expedition.

The present study represents an inventory of the existing vegetation, the management practices, the soils utilized for pasture purposes, soil fertility levels as determined by rapid tests, and other factors which tend to influence quality. It is our purpose to present the accumulated data, to evaluate the various factors, and to study the relation among them with a view toward increasing the knowledge concerning pastures.

EXPERIMENTAL

The pasture study was conducted over the State of Maryland during the summer of 1934, in the months of June, July and August. Each of the 23 counties was visited and random samples were collected from pastures in all but one. Over 400 pastures were studied on 275 farms. A total of 657 soil samples were collected and analyzed. The data here presented represent the results from 400 pastures, 400 associated soil samples, and the attendant factors. Only those records were retained which were known to be authentic and accurate.

Field Observations

Upon visiting a farm there was first obtained from the farmer all available information concerning the management practices employed. The facts, and other pertinent data, were recorded on the data sheet, a sample of which is shown in Chart I. Following this, the study of the pasture field was made, the first step of which was to observe and record such factors as topography, drainage, slope, shade and water. Soil samples were then taken with a soil auger at the uniform depth of six inches and collected in a screw-top, cardboard soil tube of one-quart capacity. Borings were made in 15 to 20 different parts of the field and the soil mixed in order to obtain a uniform representative sample. In several instances there were found in individual borings small granules of undecomposed lime which greatly affected the tests. These inclusions are the result of an application of lime which was improperly burnt or incompletely slaked. The accompanying soil sample collected from many points and homogenized showed none of the abnormal tests. An occasional sample was taken from the 6-12-inch level , or deeper, in order to more positively identify the soil series. Use was made of the soil survey reports for the counties of Maryland in identifying and locating the different soil series.

At each boring a mental note was made of the percentage composition of the immediately surrounding vegetation and, at the completion of the tour of the entire field, a record was made of the components of the vegetation and of the percentage of each. Before leaving the field a quality rating was assigned and recorded, which represented the observer's judgement as to the excellence of the turf for grazing purposes, the apparent carrying capacity in animal units to the acres, the degree of grazing, and as to other influencing factors such as placement of shade, cleanliness and freedom from weeds, trash, and other filth. This quality rating figure was based on 100 and was assigned on the basis of the theoretically perfect pasture.

Laboratory procedure

Upon being brought into the laboratory, those soil samples which had not been dried in the field were air-dried at room temperature. This method was adopted for the reason that it was found by preliminary tests, that upon rapid drying in the oven at 105°C the amounts of easily-soluble constituents were greatly increased, and subjected to a gentle crushing with a brass roller to avoid crushing any stones and to break down any clods of very large aggregate. Crushing of stones or indurated inclusions was avoided to eliminate the possibility of affecting the results of the tests by the release of greater quantities of easily-soluble materials due the increase in solubility with a reduction in particle size . . Anderson (39) found that by finely comminuting feldspar rock and grinding it in a ball mill with distilled water the pH value of the solution rose and that KOH could be extracted almost quantitatively as such. After being passed through a 12-mesh wire screen the sample was thoroughly mixed and placed in a suitable open container where it was examined for texture and again classified as to series.

The lime requirement was determined by means of the Rich-or-Poor test * in which approximately 5 grams of soil were thoroughly shaken with about 5 ml. of test solution for a period of exactly one minute. After settling for 5 minutes the depth of color of the supernatant solution was compared with a chart and a record made of the lime requirement expressed in pounds of ground limestone required for one acre to effect neutralization of the free acidity.

The pH value of the soil samples was determined by means of the Truog-Hellige outfit **, using a Triplex indicator and a neutral white powder for masking the soil color. Preliminary trials indicated that this procedure was accurate within 0.2 pH unit as compared with the potentiometer readings on the Biilmann quinhydrone electrode.

For the soil nutrient tests the procedure of Morgan (40) was employed in which 5 grams of soil were leached on a phosphorus-free filter papers with 10 ml. of sodium acetate-acetic acid of extracting solution buffered at pH 4.8 .

*Potassium thiocyanate solution sold by Urbana Laboratories, Urbana, Illinois.

** Copyrighted 1933. E. Truog. Sold by Hellige, Inc., New York.

Aliquots of the leachate were tested for dissolved Ca, Mg, P, K, NO_3, NH_3, Mn and AL, and the test readings recorded as Zero, Trace, Very Low, Low, Low Plus, Medium, Medium Plus, High, High Plus, and Very High. For the purpose of studying the test readings mathematically, arbitrary numerical values of 1 to 10, respectively in order, were assigned. Slight modifications of the Morgan procedure were adopted in order to simplify and to expedite the work. The extracting solution was delivered through a 10 ml. automatic pipette. Calcium and potassium tests were performed in spot plates instead of the shell vials after preliminary work had shown the reliability of this method. The calcium tests were made in a solid black spot plate and the potassium tests made in a clear glass spot plate on the back of which was placed a solid black background. Readings were made in groups of twelve so that greater accuracy could be obtained by intercomparisons as well as by comparison to a color chart. A nitrogen-filled bulb in a "daylight" lamp was used as the source of light to provide uniform conditions for reading the results of the tests. Frequent blank determinations were run to check the accuracy of the method and the purity and strength of the reagent solutions.

PRESENTATION OF DATA

According to the quality rating basis assigned to the pastures at the time of the field study, the 400 pasture records were separated and classed in eight quality-rating groups. The factors affecting pasture quality were analyzed for each group, on which basis they are presented, together with their percentage distribution. Eight classifications were selected because it was felt that, by a further division of pasture on a quality basis, significance of results would be reduced due to an increased error as a consequence of fewer samples in each group. A fewer number of quality groups would fail to establish the more detailed relations among the factors and significance of results would be reduced due to the fewer number of groups. The designations of "Very Poor", "Fair", "Good", and

"Excellent" are used to clarify the method used in expressing quality. Only four such designations are made since, without actually observing a pasture field, it would be difficult to convey to a reader the differences between one in the "80-89" group and one in the "above 90" group. The accompanying data in each group serve to express these differences.

Where more than one soil series occurred in a single pasture field soil samples were collected and from the vegetation studied, on each, separate records were kept so that the differences between the quality factors on the two series would be included in the analysis of the data.

Distribution of Pastures by Counties

In Table 1 are presented the data concerning the percentage distribution of the pastures studied in each county, according to the quality-rating groups. It is significant that from the counties of Frederick and Carroll, 57 and 50 per cent of the pastures, respectively, are classed in the "excellent" grouping. In the same group are 48 per cent of the pastures from Washington, but none from Allegany, Garrett, and a number of the Coastal Plain counties where a very large percentage are classed as "very poor".

Distribution of Pastures by Soil Series

The principal soil series of Maryland on which pastures are located are presented in Table 2, with the percentage distribution of pastures from each according to the rating groups. In the pastures on the Frankstown (limestone) and the Hagerstown (limestone) series we find that 92 and 72 per cent, respectively, are classed in the "excellent" group. Conversely, 58 percent of those on the Elkton and the Dekalb series are classed as "very poor". Pastures on the Ashe, Manor, Chester, and Montalto series are shown to be strikingly similar throughout.

Extent of Pasture Soil Improvement

The percentage distribution of the pastures within each quality group according to the fertilizer treatment received is shown in Table 3. Of outstanding significance are the figures which indicate that 95 per cent of all pastures in the "below 30" group receive no treatment whatever, whereas of those in the "over 90" group, only 10 percent are untreated. The use of manure alone is more prevalent than any other phase of soil improvement. In the highest quality group, however, the same number of pastures receive equally manure only, lime and manure, and the combination of lime with manure and fertilizer. Lime alone, fertilizer alone, or fertilizer with lime or manure are applied in only a small percentage of the cases studied.

The data in Table 3, is presented in different form in Table 4 in order to clarify the relation between soil treatment and pasture rating groups on the basis of the fertilizer treatment. These data show that, of all pastures which receive no treatment, 12 per cent fall in the lowest group, and 13, 15, 18, 16, 11, 10, and 5 per cent respectively for the successively higher rating groups. One outstanding point is that, of those pastures which receive lime with manure and fertilizer, 55 per cent are classed as "excellent". Fertilizer alone accounts for 50 per cent of the pastures being classed as "excellent", whereas with manure alone only 19 per cent fall into this group. The results from the use of lime alone are indicated to be slightly inferior to those when no treatment is practiced. As between lime with manure and lime with fertilizer there is but little difference.

Extent of Pasture Management Practices

The data concerning the extent to which the major unfavorable factors of management occur are grouped in Table 5. The chief factors of management, as expressed by these data, are overgrazing, undergrazing, and grazing the year around. The percentage of pastures in the "excellent" group, in which no unfavorable factors could be detected, is high. In the lower groups, however, two factors, overgrazing and year-around grazing, are outstanding.

Values of Rapid Soil Tests in Pounds to the Acre

The data in Table 6 are presented for the purpose of designating the relation between the readings of the rapid soil tests and their approximate value in pounds of the element to the acre. These values have been derived from a number of tests made on standard solutions which contain known quantities of the elements.

Distribution of Test Readings for Calcium

From an examination of the data in Table 7 it is apparent that there is a wide variation among the test readings for calcium in the various quality rating groups. There is, however, a general decline in the percentage of readings of Zero and Trace in progressing from the "very poor" to the "excellent" groups. There is similarly an increase in the number of higher test readings in the same direction. The lowest horizontal line in the table represents the derived mean numerical index which may be converted to read in pounds to the acre with the aid of Table 6. These figures further indicate the association of a high content of calcium with the better pastures.

Distribution of Test Readings for Magnesium

The distribution of test readings for magnesium (Table 8) in pasture soils indicates that a relatively large percentage of the higher readings tend to occur in the higher quality rating groups. Conversely, the lower readings tend to be associated with the poorer pastures. This is further substantiated by the figures for the mean numerical index wherein we find the higher figures in the upper quality groups.

Distribution of Test Readings for Phosphorus

The supply of phosphorus in pasture soils is indicated by the tests to be relatively low throughout, and subject to variations within a narrow range. The trend, however, as shown in Table 9, represents a relatively greater supply in the soils from pastures which are classed in the upper quality groups. In the "below 30" groups, for example, the readinf of Very Low occurred on 40 per cent of the soil samples from these pastures, and the readings of Low plus and Medium occurred in only 15 per cent of the cases. In the "excellent" group, by comparison, the same two readings occurred respectively in 21 and 29 per cent of the samples. The numerical index indicates a narrow but definite upward trend of soluble phos -

phorus with an improvement in pasture quality.

Distribution of Test Readings for Potassium

The data in Table 10 fail to give evidence of any particular trend of the supply of potassium in relation to pasture quality. With few exceptions, the distribution of the test readings in each pasture group is similar. It is only in the upper two quality groups that any definite difference can be detected. In the better pastures a higher content of soluble potassium tends to be associated with pastures of better quality.

Distribution of Test Readings for Nitrate Nitrogen

The supply of nitrate nitrogen in pasture soils, as indicated by the data in Table 11, is uniformly low and relatively constant. There can be detected , however, a slight upward trend in the supply in the soils from pastures in the upper quality groups. The total amount expressed in pounds to the acre is low, even in the soils from the better pastures.

Distribution of Test Readings for Ammonia Nitrogen

The amounts of ammonia nitrogen in pasture soils, as shown in Table 12, are relatively low, similarly with the amounts of nitrate nitrogen. The trend of the supply, however, is in the opposite direction, since the greater percentage of the higher readings are found to occur in the lower quality groups. This is shown also by the figures representing the numerical index. The readings occur within a narrow range, indicating a uniform supply in the soil.

Distribution of Test Readings for Manganese

In contrast to the readings for ammonia and nitrate nitrogen, those for manganese occur over a wide range within each of the quality rating groups. The higher readings for manganese, as shown in Table 13, occur in the greatest amounts in the soils from pastures which are classed in the lower quality groups. The trend of the supply, as indicated by the numerical index figures, is over a relatively wide range, with the smaller amounts of soluble manganese tending to be associated with the better pastures.

Distribution of Test Readings for Aluminum

An examination of the data in Table 14 clearly indicates that; (1) soluble aluminum is present in most pasture soils in relatively large amounts; (2) the percentage of the higher test readings is definitely greater in the lower quality groups while low readings tend to be associated with the better pasture; (3) the test readings occur over a wide range within the quality groups. The figures representing the numerical index definitely indicate the inverse relation between soluble aluminum and pasture quality.

Distribution of pH-value Determinations

The pH values of the pasture soils have been arranged in Table 15 in groups in which there is a spread of 0.5 pH unit. These data show that low pH values are definitely associated with pastures of the poorer types, with a corresponding association of higher values with the better pastures. It appears timely to point out that the pH range of 6.0 - 6.4 tends to occur in approximately 50 per cent of the cases within each quality group.

Distribution of Test Readings for Lime Requirement

There appears to be a definite relation between lime requirement and pasture quality as shown by the data in Table 16. This is definitely indicated by the large percentage of low readings associated with the better quality groups, and a corresponding high degree of correlation of high readings with the lower quality groups. The relation is more clearly shown by the regular progressive decline in lime requirement from the poorer quality groups to the better quality groups, as shown by the mean reading. The inverse relation of lime requirement with pH values and the calcium supply, and the direct relation with soluble aluminum is worthy of consideration.

Distribution of Pasture Forage Plants

The principal pasture forage plants which occur in Maryland pastures are listed in Table 17, together with the relative importance of each in the different quality groups, expressed as per cent of the total vegetation. The amounts of

Poa pratensis increase regularly, with the exception of the "50-59" group, from the lowest quality group to the highest. Trifolium repens increases until the highest group is reached, when it declines slightly. Digitaria species are less abundant in the better pastures whereas the accounts of Phleum pratense and Dactylis glomerata increase somewhat. Most of the minor species which occur in only small amounts are indeterminate and occur sporadically with the exception of Agrostis tenuis which is chiefly associated with the poorer types of pastures.

The total figure in the "above 90" group in Table 17 indicates that the chief desirable grasses constitute 89 per cent of the pasture vegetation. In the lowest quality group this figure is 23, the remainder of the vegetation being composed principally of weeds.

Distribution of Weedy Plants in Pastures.

The relations of weedy plants in pastures with respect to their distribution in the various quality rating groups are shown in Table 18. For the state as a whole the five weeds at the head of the list are present most universally and in the greatest abundance. With the exceptions of Danthonia spicata and Cichorium intybus in particular, the occurrence of most weedy species in the various groups appears to only a matter of degree. D. spicata, however, is found only in the four lowest quality groups and, conversely, C. intybus occurs only in the four highest quality groups. Verbascum, Solidago, Potentilla, Antennaria, Vernonia, and Pteris, are associated with D. spicata in the lowest quality groups. C. intybus, however, appears to be the only one associated with the higher quality groups. Of the species reported, only 7. 5 percent occur in the best pastures, whereas 70.9 per cent are found to occur in the pastures of the lowest quality rating group.

DISCUSSION

Field and Laboratory Procedure

The data presented have shown that pasture quality is influenced by, or associated with, a number of factors. It is the purpose of this discussion to point out the relation of the various factors to pasture quality, some of the associations among the factors, and the value and limitations of the methods employed.

"Pasture quality" is an abstract relative term incapable of precise definition. On the basis of the percentage composition of the vegetation, the condition and vigor of the forage and the degree of cleanliness, however, it is possible for an experienced observer to estimate quality with a high degree of precision. The assignations of the quality ratings in this study were made only at the time of the field visit. They represent, however, not only the condition of the pastures at the time but the observer's judgment as to their carrying capacity throughout the grazing months, as well. Some of the samples were collected during a period of drought which endured for more than a month. Others were collected during periods in which the rainfall was ample. These factors were taken into consideration when the study was made and quality ratings were assigned accordingly. It is admitted that by this method of estimating quality there is a tendency for the error to be large. In defense of the method, however, it is believed that, by studying a larger number of samples than would have been possible had more detailed methods been employed, the personal errors due to judgment tend to be reduced and to become compensating.

A considerable portion of the limestone soils of the state lie in the Piedmont region. Washington county, although not a Piedmont county, ranks high due to the predominance of the limestone soils. In a previous publication it has been shown that the limestone soils support a finer growth of pasture forage plants. The poorer rating of the Coastal Plain counties is due principally to the fact that permanent pastures are not included in the agricultural systems and the few that are maintained are largely neglected. The prevalence of the heavier soil types in the counties of the higher ratings lends support to the belief that the heavier soils are preferable for permanent pasture purposes. The lower value of sandy soils for pastures has been indicated by the productivity classification of Maryland soils (Bulletin No. 351).

<u>Distribution of Pastures by Counties and by Soil Series</u>

The data in Table 1 indicate several features concerning the location and distribution of pastures in Maryland.

The eight high-ranking counties contributed 82.7 per cent of the 400 pastures studied, the remaining 17.3 per cent being distributed over 14 counties. These eight counties lie principally in the Piedmont region, where dairying is an extensive industry, and in which the majority of the high-ranking agricultural and pasture soils are located.

Where the number of pastures studied in a county or on a soil series is low, there is a question that the data presented is not in error. By the method of study employed , however, the low figure for a county indicates that either relatively few pastures were available for study or that the agricultural system did not include permanent pastures. This is largely the case in the Coastal Plain counties where the pasture consists of grazing the aftermath of the meadows and hay fields. A low number of samples for a soil series (Table 2), indicates either its low value for pasture purposes, small total area, or both.

Portsmouth soils, for example, have a low agricultural value due to the fact that they are poorly drained. For this reason they are used chiefly for pasture purposes. Collington soils, on the other hand, are used chiefly for tobacco raising into which agricultural system permanent pastures do not fit as a part of the rotation. The Berks and the Conowingo series are both limited in extent and low in agricultural value. The water-logged condition of "Meadow" permits of summer grazing during periods of drought but does not allow it to be cultivated with success. The extensive areas of Chester and Manor soils, together with their high agricultural value, accounts for the large number of pastures studied on these soils.

<u>Pasture Soil Improvement</u>

The extent of pasture soil improvement on Maryland pastures, and the distribution of the various combinations of lime, manure, and fertilizer among the quality rating groups merits consideration. From a study of the data in Tables1 and 2 the conclusions might be drawn that soil type and soil series are highly important factors in determing pasture quality. That the soils of Maryland are highly responsive to fertilizer treatment and that neglect of soil improvement practices causes a decline in crop yields, has been well established by the work of the experiment station. The data in Tables 3 and 4 clearly show that, regardless of soil type or series, it is the kind of fertilizer treatment accorded a soil that determines the quality of pasture produced. It has been felt,that, for the most part, pastures are largely neglected for the other farm enterprises. Any attempts at soil improvement on pastures has been principally the result of a whim or of a temporary surplus of manure or other materials after the farm crops have been supplied. The data in Tables 3 and 4 further indicate that the use of manure on pastures is the most prevalent practice. This is due to the fact that manure is ordinarily the most available material, not only from the standpoint of the supply, but also due to the low cost which is an ever-present factor in fertilizing practices. The use of manure alone, however, results in a lower percentage of "excellent" pastures than where it is used in combination with lime, with fertilizer, or with both. The combination of all three materials produces the highest percentage of high quality pastures. No conclusions can be drawn from the data as to the kind of fertilizer that is most effective since in this analysis of the data many different kinds are included.

Any of the treatments in which lime is included produces a higher percentage of better quality pastures than where lime is omitted. This is in accord with the data recorded elsewhere in this study wherein a close correlation is shown to exist between lime requirement and pasture quality. The use of lime alone, however, does not appear to be an advantageous practice. Hartman and Dodd (15) found that "Where limestone was also used the fertilizers have been much more effective". This is entirely in accord with the present findings. The fertilizing value of manure has been shown by McCall and White (23) to be low, its chief value being that it supplies organic matter. Larger crop yields were found to occur when manure was applied on limed land, or reinforced with superphosphate.

The inferences to be drawn from the data in Tables 3 and 4 are : (1) lime is the first essential in producing pastures of high quality; (2) the use of manure or fertilizer in addition to lime is advantageous, but, (3) the combination of all three materials produces the highest percentage of high-quality pastures. Supporting evidence for this inference is found in data previously published wherein the limestone soils having a high pH value and a high soluble calcium content produce the best pastures in the state. The need for lime on pasture soils in Herkimer county, New York (18) is slight but it is stated that they are well supplied with lime. Under these conditions it is stated that phosphorus is the first essential in pasture improvement.

Management Practices

Among the unfavorable pasture management factors (Table 5) it is found that overgrazing and grazing the year around are the principal ones associated with pastures of low quality. Very early pasturing is likewise a considerable factor . Harrison (14) and Graber (9) found that continued close clipping of Kentucky bluegrass caused a reduction in growth and yield due to a gradual carbohydrate starvation resulting from a reduction of leaf area and photosynthetic activity. Graber states that frequent interruptions of photosynthetic activity may involve greater susceptibility to drought, lessened absorptive capacity, and increased winter and insect injury. Continued removal of top growth throughout the year likewise destroys the natural, protective soil covering and exposes thegrass roots to possible winter injury by freezing. Snow lodges in a surface growth of any kind and Weaver (35) has shown that soil temperatures beneath a snow covering may be several degrees higher than where it is unprotected. Higher winter soil temperatures are associated with a more rapid warming of the soil in the spring and, consequently, an earlier growth. Sprague (32) has shown that bluegrass plants regenerate about half of their root systems each spring, reaching a maximum in early May. He states that "..... soil and cultural conditions in early sprig are more likely to affect root development than at other seasons". This tends to show, which these data indicate, that very early pasturing is distinctly harmful to bluegrass pastures by reducing food reserve at a time when new roots are being formed.

Undergrazing as a factor contributing to low pasture quality is not so important as those aforementioned. The principal effect of this practice is to produce forage having a lower protein content and a lower nutritive ratio. This is shown by the data taken from Henry and Morrison (38) . For purposes of later comparison the data on White Clover, Crabgrass, and bent are included.

	Digestible nutrients in 100 pounds				Nutritive ratio. 1:
	Crude Protein	Carbo - hydrates	Fat	Total	
	%	%	%	%	
Bluegrass, before heading	3.7	10.4	0.8	15.9	3.3
Bluegrass, headed	2.8	16.7	0.7	21.1	6.5
Bluegrass, after bloom	1.9	21.9	0.7	25.4	12.4
White clover	3.1	9.6	0.5	13.8	3.5
Crabgrass	1.3	14.2	0.5	16.6	11.8
Bent	1.4	16.4	0.4	18.7	12.4

Bluegrass that is allowed to head out becomes unpalatable to grazing animals which tend to keep closely grazed the areas in which there is succulent, young vegetative growth. The evidence that a large percentage of the better quality pastures are undergrazed may be explained on the basis of an insufficient number of animals on unit area to maintain the pasture vegetation in an active vegetative state. The large percentage of the better quality pastures on which there were detected no unfavorable management factors is indicative of the extent of good management. The effect of clipping pastures to keep the weed growth subdued is not clearly shown by these data. The reason for this is that in many cases both the factors of infrequent clipping and overgrazing were in evidence but it was felt that the latter was the more important. By the method of analysis of the data used, it was not possible to divide the effect of each factor with the result that the factor of clipping is subjugated to that of overgrazing. Such factors as drainage and recent clearing are purely local and are without significance in relation to pasture quality inasmuch as the correction of the conditions by approved methods would eliminate them as unfavorable factors.

Chemical Tests

The relations among the different chemical tests and between pasture quality are most clearly expressed in Chart II. The results of the tests are expressed directly in pounds to the acre according to Chart I, with the exception of soluble calcium and lime requirement. Soluble calcium is reported as one-sixth, and lime requirement as one-eleventh, of the determined values. Most outstanding is the evidence of the direct association of content of soluble calcium in the soil and pH values with pasture quality. This is entirely in accord with accepted practices and furnishes additional proof of the value of lime for pasture soils. Associated with this trend is the magnesium content of the soil. Whether this is a direct factor concerned with pasture quality or whether the magnesium content is more closely associated with calcium due to the use of dolomitic limestone or to the occurrence of more of the better quality pastures on soils originating from rocks high in magnesium, is not shown by these data. The relation is significant, however, and merits further study. From a consideration of the close positive correlation of these factors with pasture quality it is to be expected that there would be a negative correlation with respect to the lime requirement of pasture soils. This is precisely what has been found in this study, and attention is directed to the extremely close agreement. The same degree of correlation is found in a similar direction in the content of soluble aluminum in pasture soils. This clearly indicates that by the increase in the lime content of a soil the easily soluble aluminum compounds are rendered less soluble. It has been shown (18)(20) that aluminum toxicity is a probable factor in the metabolism of plants and, hence, a factor which affects pasture quality.

From the data presented, it is difficult to draw positive conclusions with respect to the amounts of soluble potassium in pasture soils and pasture quality. This may be due to two reasons. Most Maryland soils contain potassium compounds in relatively large amounts which become soluble in sufficient amounts to satisfy the requirements of forage plants. In this event potassium is not a limiting factor for plant growth, and hence in determining pasture quality. The other possibility is that the rapid tests for this element are insufficiently accurate to determine the association. The first explanation is the more probable since, in field crop experiments in Maryland, it has been found that the applications of potassic fertilizers, particularly on the heavier soils, have little influence on yields.

The supply of soluble phosphorus in Maryland pasture soils is low but the definite trend in the curve shown in Chart II clearly indicates that phosphorus is a factor concerned with pasture quality. It is felt that by applying a more sensitive test for phosphorus the true relation might be more clearly shown. Since phosphorus is present in Maryland soils in only relatively small amounts , and since it is being continually removed by growing plants, the conclusion is drawn that this element constitutes one of the chief limiting factors associated with pasture quality. The importance of phosphorus for the improvement of pasture quality is stressed by the work of Johnstone-Wallace (18) who states that "phosphorus is the first essential in the fertilization of Herkimer County (N.Y.) pastures." The curve for phosphorus in Chart II indicates that only a relatively small (5 pounds to the acre of P) change in the amount of the element in the soil is associated with relatively great changes in the vegetation and pasture quality. The inference is drawn that the rapid test for phosphorus is less sensitive in detecting a deficiency than, are the principal forage plants.

Attention is drawn to the positive relation of soluble phosphorus with soluble calcium which indicates the more available nature of calcium compounds in comparison with iron and aluminum compounds.

The form in which phosphorus exists in the soil, whether in combination with calcium or in combination with iron and aluminum, may have considerable bearing upon the amounts of phosphorus that are easily-soluble and available to plants. There exists between soluble calcium and soluble phosphorus a strong positive correlation as regards their relative abundance as indicated by the rapid soil tests. Similarly, there is an equally strong negative relation of soluble phosphorus with soluble aluminum. With the higher amounts of soluble aluminum there is an associated larger quantity of soluble iron, both of which tend to combine with soluble phosphorus in the lower pH ranges and to render it less soluble.

The curves for nitrate nitrogen and for ammonia nitrogen indicate a small but rather constant supply of both in pasture soils. This is in accordance with accepted findings inasmuch as both are utilized by grasses. Whereas we find a direct relation between nitrate nitrogen and pasture quality, the converse is true with respect to ammonia nitrogen. This again is in accordance with the observed data concerning pH values and lime content. In the soils that are plentifully supplied with lime there is greater bacterial action (3) and ammonia nitrogen is quickly converted into nitrate nitrogen. The amounts of nitrate nitrogen, even in the better pastures, are seldom high due to their rapid absorption by the grass plants. The higher amounts of ammonia nitrogen in the poorer pastures and the converse with respect to nitrate nitrogen, is also a function of drainage and aeration. Ammonia nitrogen tends to accumulate under conditions of poor aeration and drainage due to the exclusion of air and to the consequent limited bacterial activity.

The relation between manganese and pasture quality does not appear to be a constant one but in general it is inverse. The association of low manganese content with the better pastures indicates that there may be an actual manganese, as well as aluminum, toxicity. On the other hand, it is probable that the content of soluble manganese in pasture soils is a function of the calcium content or of the acidity represented by the pH value. Solutions of low pH value tend to enhance the solubility of manganese compounds whereas solubility is inhibited by more alkaline solutions. Evidence for the manganese -tolerance of pasture forage plants is lacking. The data do not show the true picture inasmuch as the test readings on many of the Coastal Plain pasture soils showed that there is a possibility of a manganese deficiency which is associated with the poor pastures in that section of the state. These data indicate only a trend but, at the same time, they suggest the possibility that manganese may be a limiting factor as regards both toxicity and a deficiency.

Pasture Forage Plants

It is only logical that, since the assignation of the pasture quality ratings was made largely on the basis of the vegetation, the amounts of Kentucky bluegrass and of white clover show a direct relation to pasture quality. It is the amounts of each in the various quality groups that appear significant. In the first five groups White Clover exceeds Kentucky bluegrass in amount. In the sixth group (70-79) there is a 1:1 ratio; in the higher quality groups the bluegrass predominates. This does not necessarily indicate that higher quality ratings were assigned to pastures containingmore bluegrass than clover. Previous work (10) (11) shows that bluegrass predominates over clover on the limestone soils and that a high percentage of pastures on these soils were classed in the upper quality groups. The predominance of clover over bluegrass in the poorer pastures indicates the ability of clover to grow at the expense of the grass on soils of low fertility, and the greater tolerance of clover to unfavorable soil and climatic conditions.

The level of fertility as indicated by the soil tests is shown to be much more of a limiting factor in the growth of Kentucky bluegrass and White clover than the soil type or the soil series. This is supported by the close correlation between soil fertility and amounts of the main pasture forage plants and a much more scattered distribution of soil series with respect to pasture quality. Higher soil fertility produces not only a greater quantity of forage but forage of a higher quality due to the absorption of greater amounts of nutrients, particularly calcium and phosphorus.

Crabgrass furnishes a considerable portion of the summer grazing in many pastures, particularly in the Coastal Plain and the poorer Piedmont pastures where grazing is begun early and it is not suppressed by a heavy growth of the more desirable grasses. The small amount of crabgrass reported in the poorest pasture group is due to the high percentage of mountain pastures which fall in this group in which crabgrass is an inconsiderable factor due either to altitude, soil conditions or both. In the second, third and fourth groups crabgrass exceeds in abundance both bluegrass and White clover. It is chiefly in these groups that the Coastal Plain pastures occur where, without crabgrass, there would be very little summer pasture. The fact that crabgrass contains a low protein content and a low nutritive ratio (38) is of small concern to farmers who depend upon this grass for summer grazing.

Bent grass is even less desirable in pastures than crabgrass. The nutritive ratio is lower while the protein content is similar to that of crabgrass. It occurs chiefly in the mountain pastures on thin, poor soil where, in many cases, it furnishes a large part of the grazing. Small amounts are found in the more poorly drained areas of Coastal Plain pastures. The tolerance of bent grass to high acidity is borne out by these data. Redtop occurs in about the same degree in all pastures, regardless of the chemical nature of the soils or of the other influencing factors. The percentage of timothy and orchard grass in pastures is comparable, with the larger amounts found in the better pastures. They are not as sensitive to fertility and management as bluegrass and white clover. Black medic occurs chiefly in Coastal Plain pastures where it furnishes considerable grazing. As a pasture forage plant it belongs with Bermuda grass in being of greater value in the Southern states. Fescue occurs in only a few pastures and in very small amounts. It is found chiefly in connection with the more droughty soils, on hillsides and stony slopes. Lespedeza is included in the pasture forage plants principally to indicate the extent to which it is being used for pasture purposes. The figures for Canada bluegrass show no definite relation to pastures of either high or low quality. It occurs in relatively greater amounts on the lighter, poorer soils since it is largely supplanted by Kentucky bluegrass under good management practices. <u>Panicum</u> and <u>Paspalum</u> species are of little value nor are they of much significance. They occur in the poorer pastures only and represent an invasion as the result of the disappearance of the more desirable plants.

Pasture Weeds

Plantago spp. appear to be the most widely distributed and present in the largest amounts in every quality group except the lowest where Danthonia spicata is more prevalent. Species of Chrysanthemum and Erigeron are likewise widely distributed. An interesting and significant feature is that all of these weeds decrease under proper soil improvement and grazing management practices. This is largely true of most of the species reported with a few exceptions. Echium, vulgare, Asclepias, and Cichorium tend to prefer the more fertile soils, which are high in content of soluble calcium. They are apparently little influenced by the usual management practices. Potentilla and Antennaria are distinctly associated with infertile soils and poor pastures but they readily disappear under good management. Anthoxanthum appears to be associated more with overgrazing than with any other single factor since it occurs on soils that are both poorly drained and well drained, fertile or infertile. The total weeds in proportion to the total forage plants for the different quality groups indicate the importance of these factors in determining pasture quality.

SUMMARY

An inventory analysis of permanent pastures in Maryland was made for the purpose of determining the extent, the scope and the distribution of the factors affecting pasture quality, and the relations among them. Observations were made on a large number of pastures. Soil samples were collected at the time of the analysis of the vegetation, and brought into the Laboratory for identification and for soil tests.

Among the factors considered were; soil types, topography and drainage, cultural and management practices. The soil tests included determination of pH values, lime requirement, and readily-soluble calcium, magnesium, phosphorus, potassium, nitrate and ammonia nitrogen, manganese, and aluminum. These factors and tests were classed according to their distribution by quality ratings assigned at the time of the field inspection.

The relatively few counties which contribute the majority of the better quality pastures are located principally in the Piedmont region, where the heavier-textured soils occur. Whereas, there is some tendency for soil series to be associated with pasture quality it has been found that thelevel of fertility is the most important factor in determining pasture quality. In this respect, there are four groups of closely-related pasture soils ranking respectively, the limestone soils, the Piedmont soils, the Coastal Plain soils, and the mountain soils.

Among the fertilizer treatments the use of manure alone is the most prevalent but pastures of lower quality are produced than when it is supplemented with lime, with fertilizer, or with both materials. The use of all three materials in combination yielded the treatest percentage of high-quality pastures. Lime increased the efficiency of the fertilizer treatments but when used alone it was no more satisfactory than where no treatment was accorded the pasture.

Among the unfavorable management practices the chief ones in determining pasture quality are overgrazing and grazing the year around. Undergrazing is associated with the better pastures and is considered unfavorable due to the production of

pasture forage of lower quality. Drainage, recent clearing, and other factors are chiefly local in extent. Infrequent clipping is a serious factor.

There was found by the rapid soil tests to be a direct relation between pasture quality, the pH value of the soil, and the amounts of easily-soluble calcium, phosphorus, magnesium and nitrate nitrogen. An inverse relation was found between pasture quality, the lime requirement of the soil, and the amounts of easily-soluble aluminum, manganese, and ammonia nitrogen. High soil fertility produces not only more forage but forage of higher quality and feeding value. The amounts of ammonia and nitrate nitrogen, and soluble phosphorus and magnesium in pasture soils are generally low. There is reported the possibility of manganese toxicity in the heavier-textured pasture soils of low pH, and a manganese deficiency in Coastal Plain pasture soils. There can be detected no evidence that soluble potassium is a limiting factor for the growth of pasture grasses. The relatively great changes in vegetation with a very narrow gradient in the supply of soluble phosphorus clearly indicates this element to be the chief limiting factor affecting pasture quality. The direct association of magnesium with pasture quality indicates that there is a possibility that this element may be a limiting factor.

There is a close negative correlation of the content of soluble aluminum with pasture quality and with lime requirement, and an equally close inverse relation with the pH value and the content of soluble calcium. Of the rapid soil tests these four are highly significant in determining the level of fertility in pasture soils. The test for soluble phosphorus is considered to be of equal importance when its association with, and its interpretation on thebais of the other soil tests are taken into consideration.

The chief pasture forage and pasture weed plants and their occurrence among the quality rating groups are enumerated. The chief forage plants in order of their importance in the better pastures are: Kentucky bluegrass, White clover, crabgrass, redtop, timothy, orchard grass, and Canada bluegrass. The chief weed species in the poorer pastures are: plantain, poverty grass, five-finger, daisy, sour dock, white top, and brown sedge.

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TABLE 1

PERCENTAGE DISTRIBUTION OF PASTURES FROM EACH COUNTY ACCORDING TO THE QUALITY RATING GROUPS

County	Number of Pastures	Per cent of Total	Very Poor		Fair		Good		Excellent	
			below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
			%	%	%	%	%	%	%	%
Frederick	46	11.5			4	13	6	19	33	24
Carroll	52	13.0			6	2	11	31	17	33
Queen Anne's	3	.7					33	33	34	
Washington	25	6.2	4		16	12	4	16	16	32
Baltimore	38	9.5	8		8	3	18	21	26	16
Howard	28	7.0		7		25	19	21	21	7
Talbot	3	.7				67				33
Harford	83	21.0	5	14	5	16	8	12	16	24
Montgomery	27	6.8			22	22	19	15	15	7
Cecil	31	7.7	3	13	16	13	13	13	3	26
Kent	9	2.2	11	23		11	11	22	11	11
Dorchester	2	.5		50					50	
Caroline	2	.5		50					50	
Prince George's	10	2.5	20		30		20	20	10	
Somerset	5	1.2			40	20	40			
Anne Arundel	1	.25				100				
Worcester	5	1.2	20	20			40		20	
St. Mary's	5	1.2		20		60	20			
Wicomico	4	1.0		25	25		50			
Garrett	14	3.5	28	14	7	36	14			
Allegany	6	1.5	50	17		16		16		
Charles	1	.25		100						
Calvert										

TABLE 2

PERCENTAGE DISTRIBUTION OF PASTURES OCCURRING IN THE QUALITY RATING GROUPS BY SOIL SERIES

	Number of Pastures	Per cent of Total	Very Poor		Fair		Good		Excellent	
			below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
State	400	100	5	7	8	14	13	17	17	19
			%	%	%	%	%	%	%	%
Frankstown	12	3.0						8	17	75
Hagerstown	25	6.2			4		12	12	32	40
Congaree	33	8.2			3	3	6	30	33	25
Penn	15	3.8			7	7	13	20	40	13
Bermudian	11	2.8				10	27	27	18	18
Huntington	3	.7				33			67	
Ashe	7	1.7			14	14		44	14	14
Manor	83	21.0	4	6	7	14	12	20	16	21
Chester	92	23.0	1	9	9	15	14	17	14	21
Montalto	15	3.8	13	7	13	7		27	13	20
Sassafrass	44	11.0	3	17	7	14	30	11	9	9
Meadow	4	1.0			50	25			25	
Elkton	7	1.7	14	44	14				14	14
Berks	2	.5			50	50				
Portsmouth	2	.5			50	50				
Keyport	5	1.2	20		20	40	20			
Upshur	5	1.2	20		20	60				
Collington	4	1.0	25		50	25				
Dekalb	17	4.2	41	18	6	18	12	5		
Conowingo	5	1.2	40	20		40				

TABLE 3

PERCENTAGE DISTRIBUTION OF PASTURES IN THE STATE AND IN EACH QUALITY RATING GROUP AS INFLUENCED BY FERTILIZER TREATMENT

Fertilizer treatment	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
None	39	95	70	68	54	50	45	22	10
Manure only	26	5	10	29	29	27	33	26	26
Manure and lime	18		7		4	12	33	29	26
Manure, lime and fertilizer	9		3	3	2	4	8	9	26
Fertilizer and lime	4		3		5			10	10
Lime only	2		7		5	4	2		
Fertilizer only	1				1	1			2
Fertilizer and manure	1					2		3	

TABLE 4

PERCENTAGE DISTRIBUTION OF PASTURES IN THE STATE AND IN FERTILIZER TREATMENT GROUPS BY QUALITY RATING GROUPS

Fertilizer treatment	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
None	39	12	13	15	18	16	11	10	5
Manure only	26	1	3	10	15	13	21	18	19
Manure and lime	18		3		3	8	30	28	28
Manure, lime and fertilizer	9		3	3	3	5	14	17	55
Fertilizer and lime	4		6		18			41	35
Lime only	2		12.5		37.5	25	12.5		
Fertilizer only	1				25	25			50
Fertilizer and manure	1					33		67	

TABLE 5

PERCENTAGE DISTRIBUTION OF PASTURES IN THE STATE AND IN EACH QUALITY RATING GROUP AS INFLUENCED BY UNFAVORABLE MANAGEMENT PRACTICES

Unfavorable Management Factors	All Pastures	Very Poor: below 30	30-39	Fair: 40-49	50-59	Good: 60-69	70-79	Excellent: 80-89	over 90
	%	%	%	%	%	%	%	%	%
None	27.5		10		18	20	33	43	48
Undergrazed	23.0			12	7	27	27	29	42
Overgrazed	21.0	40	38	35	24	21	18	16	9
Grazed year around	9.5	40	24	29	7	10	3	1	1
Drainage	6.5			15	16	8	6	6	
Very early pasturing	4.0		14	9	9	4	2	1	
No clipping	4.0				11	4	9	3	
Prior overcropping	1.5	10				2	2		
Recent clearing	1.5	10	7		2	2			
Other causes	1.5		7	6					

TABLE 6

APPROXIMATE VALUE IN POUNDS TO THE ACRE FOR LETTER SYMBOLS OF EACH ELEMENT REPORTED IN SOIL TESTS

Plant Food as Individual Elements	Pounds to the acre* of the elements as designated by the following letters and numerals								
	O 1	T 2	VL 3	L 4	L+ 5	M 6	M+ 7	H 8	VH 9
Nitrogen as Nitrate	None	4	8	15	20	30	40	50	75
Nitrogen as Ammonia	"	2	4	8	12	20	30	50	75
Phosphorus	"	5	10	20	30	50	80	150	250
Potassium	"	50	100	150	200	250	325	400	600
Calcium	"	200	400	800	1200	1600	200	2400	3600
Magnesium	"	-	16	25	40	60	75	150	250
Manganese	"	4	8	12	16	28	40	60	100
Aluminum	"	10	25	50	60	100	160	250	500

*Calculated on basis of 2,000,000 pounds of surface soil to the acre.

TABLE 7

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE CALCIUM BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below: 30	30-39	40-49	50-59	60-69	70-79	80-89	over: 90
	%	%	%	%	%	%	%	%	%
O	2	25	14						
T	25	25	34	35	35	16	24	24	17
VL	16	10	28	15	15	27	13	7	17
L	17	5	3	26	20	10	25	21	15
L+	16	15	14	9	7	25	16	21	17
M	14	20	7	6	11	18	12	19	16
M+	4			3	6	2	8		8
H	4			6	6	2	2	5	8
H	1							3	1
VH	1								1
Mean numerical Index	4.11	3.20	2.90	3.68	3.94	4.08	4.07	4.43	4.67

TABLE 8

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE MAGNESIUM BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below: 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O									
T	1	5		3				1	1
VL	33	60	45	44	40	16	30	33	25
L	32	25	24	32	26	53	36	25	33
L+	12	5	17	6	14	4	16	13	15
M	15		10	12	13	25	10	24	13
M+	5	5	4	3	2	2	6	1	12
H	2				5		2	3	1
H+									
VH									
Mean numerical index	4.30	3.50	4.00	3.88	4.27	4.48	4.31	4.41	4.54

TABLE 9

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE PHOSPHORUS BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below: 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O									
T	9	20	3	12	13	6	10	5	5
VL	33	40	42	38	33	45	33	31	21
L	37	25	38	32	36	32	28	46	45
L+	16	15	14	12	18	17	20	9	22
M	5		3	6			9	9	7
M+									
H									
H+									
VH									
Mean numerical index	3.76	3.35	3.72	3.62	3.60	3.60	3.84	3.84	4.04

TABLE 10

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE POTASSIUM BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O	17	20	17	17	18	17	17	19	15
T	26	25	10	23	27	27	33	23	29
VL	22	25	45	27	22	22	15	25	13
L	15	20	15	15	18	16	13	10	19
L+	10	5	3	9	9	6	15	13	12
M	4	5	3	3	4	6	2	3	5
M+	1			3		2			1
H	4		7	3	2	4	5	7	5
H+	1								1
VH									
Mean numerical index	3.17	2.80	2.65	3.12	2.93	3.14	2.66	3.22	3.39

TABLE 11

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR NITRATE NITROGEN BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor: below 30	Very Poor: 30-39	Fair: 40-49	Fair: 50-59	Good: 60-69	Good: 70-79	Excellent: 80-89	Excellent: over 90
	%	%	%	%	%	%	%	%	%
O	47	65	52	53	47	61	45	34	43
T	26	15	31	29	33	21	27	32	20
VL	7	10	3	6	11		4	12	4
L	11		7	9	5	8	20	10	13
L+	5	10		3	4	6		2	15
M	3		7			4	3	6	5
M+									
H	.75						1	3	
H+	.25							1	
VH									
Mean numerical index	2.15	1.75	1.93	1.79	1.85	1.88	2.19	2.54	2.51

TABLE 12

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR AMMONIA NITROGEN BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O									
T	6	10			2	9	3	6	12
VL	26	15	28	24	18	29	27	25	34
L	48	40	52	50	56	39	49	53	42
L+	18	25	17	23	18	22	21	15	12
M	2	10	3	3	4			1	
M+	Tr				2				
H									
H+									
VH									
Mean numerical index	3.84	4.10	4.00	4.06	4.09	3.72	3.88	3.81	3.54

TABLE 13

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE MANGANESE BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O	5	5	10	9	7	2	2	4	6
T	17	5	10	12	6	20	15	27	25
VL	13	5	7	3	9	21	12	16	16
L	23	25	24	20	27	27	26	13	21
L+	16	20	7	17	20	14	15	19	17
M	14	10	28	15	16	12	11	13	8
M+	4		4	6		2	9	5	4
H	7	20	10	15	13	2	8	3	3
H+	1	10		3	2		2		
VH									
Mean numerical index	4.27	5.40	4.55	4.85	4.70	3.84	4.60	3.88	3.70

TABLE 14

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR EASILY-SOLUBLE ALUMINUM IN PASTURING SOILS BY QUALITY RATING GROUPS

Test Reading	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
O	Tr							2	
T	7		3		2	8	5	9	17
VL	15			6	5	14	15	22	28
L	22	10		21	18	27	27	24	29
L+	13	10	21	6	22	8	16	10	11
M	22	10	28	26	24	23	27	23	13
M+	4	15	10	3	7	2		4	1
H	15	45	31	29	22	18	9	6	1
H+	2	10	7	9			1		
VH									
Mean numerical index	5.11	7.05	6.59	6.23	5.69	5.04	4.90	4.50	3.84

TABLE 15

PERCENTAGE DISTRIBUTION OF pH-VALUE READINGS OF PASTURE SOILS BY QUALITY RATING GROUPS

pH-Value Groups	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-70	80-89	over 90
	%	%	%	%	%	%	%	%	%
4.0 - 4.4	.5	10							
4.5 - 4.9	3	15	14	6	3		1	1	
5.0 - 5.4	10	10	24	14	13	8	15	7	
5.5 - 5.9	17.5	20	10	30	35	25	12	10	8
6.0 - 6.4	48	40	52	38	40	61	49	48	50
6.5 - 6.9	11	5		12	2	4	13	21	17
7.0 - 7.4	6				2	2	9	7	16
7.5 - 7.9	3				2		1	3	9
8.0 - 8.4	1				3			3	
8.5 and over									
Mean pH value	6.01	5.54	5.66	5.81	5.97	6.03	6.13	6.32	6.55

TABLE 16

PERCENTAGE DISTRIBUTION OF TEST READINGS FOR LIME REQUIREMENT IN PASTURE SOILS BY QUALITY RATING GROUPS

Lime requirement readings in pounds to the acre	All Pastures	Very Poor		Fair		Good		Excellent	
		below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%	%
0	15			9	9	4	18	16	38
100	7			6	2	4	6	15	12
250	16	20	14	9	13	14	17	19	21
500	14	10	14	12	14	20	15	9	16
750	6	5	10		9	8	4	10	1
1000	14	10	10	12	24	16	16	16	5
1500	10	15	10	17	9	18	9	6	3
2000	7	10	14	14	7	8	6	4	4
2500	3		7	6	5	2	2	3	
3000	3	10	7	6	4	6	3	2	
3500	1			3			1		
4000	2		10		4		3		
5000	1	5		3					
6000	1	15	4	3					
Mean reading	954	2112	1722	1513	1093	1008	872	640	325

TABLE 17

PRINCIPAL PASTURE FORAGE PLANTS EXPRESSED AS MEAN PER CENT OF TOTAL VEGETATION BY QUALITY RATING GROUPS

Forage Plants	Very Poor		Fair		Good		Excellent	
	below 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%
Poa pratensis L. (Kentucky bluegrass)	2.5	4.8	12.0	10.0	14.7	22.2	31.3	45.8
Trifolium repens L. (White clover)	2.9	8.3	15.1	14.6	21.0	22.7	26.4	25.1
Digitaria spp. (Crabgrass)	7.0	15.9	16.3	14.8	13.2	16.1	13.6	8.2
Agrostis alba L. (Redtop)	1.4	3.6	3.1	2.5	3.3	4.0	2.6	3.4
Phleum pratense L. (Timothy)	0.4	1.6	1.0	1.9	3.6	4.3	2.4	3.0
Dactylis glomerata L. (Orchard grass)	0.0	0.2	0.6	2.1	1.0	1.3	1.8	2.5
Agrostis tenuis (Bent grass)	4.2	4.7	1.2	4.3	2.6	0.7	0.8	
Poa compressa L. (Canada bluegrass)	0.8	1.3	1.8	2.2	2.8	1.0	1.6	0.9
Medicago lupulina L. (Black medic)	0.9	2.6	1.8	1.6	0.5	Tr	0.3	0.1
Festuca spp. (Fescue)	0.7			0.3				
Les pedeza spp. (Lespedeza)	0.2			0.4	1.2	0.5	Tr	
Paspalum spp. (Paspalum)	1.6		1.0	0.2				
Cynodon dactylon L. (Bermuda grass)		0.5		0.4				
P anicum spp. (Panicum)	0.4			Tr				
TOTAL FORAGE PLANTS	23.0	43.5	53.9	55.3	63.9	72.8	80.8	89.0

TABLE 18

PRINCIPAL WEEDY PLANTS OF PASTURES EXPRESSED AS MEAN PER CENT OF TOTAL VEGETATION BY QUALITY RATING GROUPS

Weedy Plants	Very Poor		Fair		Good		Excellent	
	below: 30	30-39	40-49	50-59	60-69	70-79	80-89	over 90
	%	%	%	%	%	%	%	%
Plantago spp. (Plantain)	11.4	14.5	12.6	9.7	9.4	7.1	5.7	3.3
Ambrosia spp. (Ragweed)	2.8	4.8	4.0	2.9	3.5	2.3	1.7	0.9
Chrysanthemum spp. (Daisy)	5.0	4.8	3.1	2.1	2.3	1.3	0.6	0.2
Erigeron spp. (Whitetop)	4.5	3.3	1.7	3.7	3.8	3.1	1.2	0.4
Rumex acetosella L. (Sour dock)	4.2	4.3	1.3	1.5	1.3	0.4	0.3	Tr
Daueus carota L. (Carrot)	2.6	0.6	1.3	1.4	1.0	0.5	0.3	
Achillea millefolium L. (Yarrow)	1.7	1.9	0.9	1.2	1.0	0.8	0.2	0.1
Rumex crispus L. (Curly dock)		1.0	1.1	0.5	0.9	0.8	0.2	0.4
Echium vulgare (Blue Devil)		0.6	0.6	0.8	1.4	0.6	0.7	0.7
Carex spp. and Juneus spp . (Reeds and Rushes)	1.4	2.5	2.5	3.2	2.0	0.7	0.4	0.1
Carduus spp. and Cirsium spp. (Thistles)		1.5	1.3	0.9	1.0	1.0	1.2	0.5
Potentilla spp. (Five-finger)	8.4	2.3	0.8	0.4				
Polygonum spp. (Smartweed)		1.5	2.1	1.4	1.7	1.0	0.6	
Antennarra spp. (Cat's paw)	2.2	1.2	1.5	Tr				
Dauthonia spicata L. (Poverty grass)	13.8	1.7	5.1	5.1				
Anthoxauthum odoratum L. (Sweet Vernal)	4.5	0.4	0.4	1.2	0.8	1.0	Tr	0.1
Andro pogon spp. (Broom sedge)	4.6	2.1	1.2					
Solidago spp. (Goldenrod)	0.8	0.4	0.3	0.5				
Verbascum spp. (Mullein)	0.8	0.8	0.3	Tr				
Pteris spp. (Common brake)	1.8	0.2						
Vernonia spp. (Ironweed)	0.4	0.2		0.3				
Asclepias spp. (Milkweed)		0.4	0.7	1.2	0.5	0.5	0.5	0.4
Cichorium intybus, L. (Chicory)					0.6	0.2	0.3	0.4
TOTAL WEEDS	70.9	51.0	42.8	37.8	31.2	20.5	13.9	7.5

CHART I - Sample record of pasture data

MARYLAND PERMANENT PASTURE STUDIES

Field Record

Date June 26,1934

No. 102

Observer Fred V. Grau

Owner's name Hamilton Amoss

Address Fallston

Location: County Harford

District

Soil Manor loam Subsoil micaceous

Topography gently rolling Drainage good

Farming System Dairy Pasture Acreage 40 Head and age of stock 40 Age of pasture 20

Liming: Date(s) 1931- every 3 years Amounts(s) 1200 pounds hydrated

Fertilizing: Date(s) 1933 Amounts(s) 600 pounds/acre Composition 0-12-5

Flowing stream: Yes x No Width 3' Continuous: Yes x No Shade: Yes x No Date first pasturing May 5

Botanical Data

Forage Plants (95 per cent) Name	Amt.	Weeds (5 per cent) Name	Amt.	Shrubs Name	Amt.	Trees Name	Amt.
Kentucky bluegrass	60	Plantain	20	none		tulip poplar	
White clover	30	Thistle	20			oak	
Redtop	5	Bull nettle	60				
Timothy	5						

Remarks:

99 rating. Hauls manure from barn to pasture . Undergrazed.

Laboratory Record

Sample No.	Depth	Soil	pH	Lime Tests: Comber	Lime Tests: Ca	Soluble Constituents: Mg	P.	K.	Nitrogen: NO_3	Nitrogen: NH_3	Mn	Al
102	6"	Manor loam	6.5	0	L+	M +	M	L+	L+	L	M	VL

CHART II- RELATIONS AMONG RESULTS OF TESTS ON PASTURE SOILS BY QUALITY RATING GROUPS.